TRANSACTIONS

OF

THE AMERICAN SOCIETY

OF

HEATING AND VENTILATING ENGINEERS

VOL. IV.

FOURTH ANNUAL MEETING

NEW YORK, JANUARY 25-27

1898

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AT THE OFFICE OF THE SECRETARY
NEW YORK CITY

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XXXVIII.

THE AMERICAN SOCIETY

OF

HEATING AND VENTILATING ENGINEERS.

FOURTH ANNUAL MEETING.

New York City, Jan. 25, 26, 27, 1898.

PROCEEDINGS.

The meeting was called to order at 11 A. M. on Tuesday, January 25, by the President of the Society, Mr. W. M. Mackay, in the auditorium of the American Society of Mechanical Engineers, No. 12 West Thirty-first street, New York city.

The following members and guests were registered as being in attendance:

MEMBERS.

Henry Adams.
N. P. Andrus.
Homer Addams.
Thomas Barwick.
H. J. Barron.
C. C. Buck.
Frank K. Chew.
John A. Connolly.
R. C. Carpenter.
B. H. Carpenter.
Geo. B. Cobb.
Albert A. Cryer.
T. B. Cryer.
R. Campbell.
William H. Dewey.
Mark Dean.
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A. H Fowler.
John Gormly.
J. A. Goodrich.
Jas. W. Gifford.
Andrew Harvey.
R. C. Hankin.
Chas. F. Hauss.
H. A. Joslin.
S. A. Jellett.
A. E. Kenrick.
Wm. M. Mackay.
Henry C. Meyer, Jr.
Wm. McMannis.
Ed. A. Monroe.
William H. McKiever.
A. C. Mott.
Andrew G. Paul.
G. I. Rockwood.
Henry H. Ritter.
J. C. Sorgen.
B. F. Stangland.
H. M. Swetland.
Geo. P. Steel.
L. B. Sherman.
E. N. Squires.
U. G. Scollay.
Percival H. Seward.
F. A. Williams.
W. S. Washburn.
Geo. H. Weymouth.
Wiltsie F. Wolff.

GUESTS.

Leicester Allen, New York.
John K. Allen, Chicago, Ill.
William A. Boringe, New York.
F. H. Bowen, Collegeville, Pa.
W. M. Brownback, Philadelphia, Pa.
Jas. Englis, Detroit, Mich.
Henry G. Gombers, New York.
E. J. Heatherton, New York.
A. T. Henderson, New York.
Thomas Hyde, Albany, N. Y.
Jas. M. Heatherton, New York.
Henry L. Hall, New York.
William Kent, New York.
G. M. Langdon, Hartford, Conn.
T. C. Mathews, Elmira, N. Y.
H. P. Stauffer, Landisville, Pa.
H. R. Stickney, New York.
Jos. R. Vance, Geneva, N. Y.
Hayden W. Wheeler, Brooklyn, N. Y.
F. M. Wilmot, New Haven, Conn.

After calling of the roll by the secretary and the passage of a resolution dispensing with the reading of the minutes of the previous meeting, since they had already been distributed in printed form, the President, Mr. William M. Mackay, then read the following address:

PRESIDENT'S ADDRESS.

Gentlemen and Members of the American Society of Heating and Ventilating Engineers: It gives me pleasure to welcome you to this, our fourth annual meeting, which I trust will prove interesting and beneficial to all. While there has been no marked improvement in the condition of business or trade during the past year, our society has not suffered from the general depression, but has grown steadily in point of numbers, those admitted to membership during the year amounting to fully twenty-five per cent. of our former membership, and coming from all sections of this country and Europe, showing that the interest manifested in advancing this our chosen profession is not local but universal.

No special effort has been made to increase the membership of the society, the majority of the applicants soliciting the honor rather than being solicited, which would indicate a recognition of the standing of the society and the necessity for a united action to elevate and advance our profession.

Our society has already been the means of accomplishing much good in diffusing a knowledge of the requirements and the best methods employed in securing good heating and ventilation, which we claim to be a necessity, and while some have felt that the imparting of information and data gained by years of application and study and sometimes by a larger expenditure of money used in costly experiments would be injurious to the occupation of the heating and ventilating engineer, it has been found that a more general public knowledge of the requirements and apparatus best suited for accomplishing the purpose has increased the demand for competent heating and ventilating engineers and the use of scientifically designed materials and systems of heating and ventilation. Still, what has already been accomplished sinks into insignificance when compared with the possibilities of a society like ours with a membership embracing the leading men in the profession in all sections of the country. A united effort on the part of the individual members of the society will in time awaken the different state and muncipal governments to the fact that good heating and ventilation are necessities and not luxuries, and will secure for our profession the same

recognition and legislation as is accorded to other professions of no greater importance.

To accomplish the greatest amount of good for ourselves and others it is desirable that we should avail ourselves of every opportunity to advance the interests of the society, and that in electing officers and appointing committees, we should select those who can best fill the different positions and who are willing to devote a reasonable amount of time to the affairs of the society. We should also endeavor to increase our membership by securing as members or juniors all who are eligible for such membership. This can be best accomplished by the individual members in the different sections of the country where they are located. The officers of the society can be assisted in conducting its affairs by a free discussion on the part of the members of Topic No. 4, presented at this meeting.

The members will be called upon to vote on several additions and amendments to our Constitution, as recommended by the committee appointed to consider this matter at the last annual meeting and handed in in writing by the members.

The first change suggested is to strike out the age limit for members and juniors; the second amendment relates to the meetings of the Board of Managers and the Council and defines more clearly the duties of the Council.

The third amendment provides that our Constitution may be amended at any regular meeting of the society by notifying the members of such amendment in writing at least sixty days in advance of the annual meeting.

The fourth amendment is to correct an error in regard to those entitled to vote; and the fifth amendment provides that the president and secretary shall be members of the Council as well as members of the Board of Managers, and that by this change the Council be increased to seven instead of five members.

As all of these changes, as suggested, are the result of careful consideration, and seem to be for the best interests of the society, I would ask for them your attention, consideration and judgment. We have adopted a society badge or button; it is worn by a number of our members, and I would suggest that all of our members who wish to be known as belonging to our society, procure and wear this emblem. A number of our members use the name of the society on their stationery and cards; it is desirable that all members should avail themselves of this privilege.

The question of a summer meeting as provided for in our bylaws was left in the hands of the Board of Managers with power at

our last annual meeting, and they arranged a meeting at the Windsor Hotel, in this city, on the evening of June 18, 1897.

That meeting was so successful, so largely attended and brought our society into such prominence that I would strongly urge that you follow the same course this year.

Our Committee on Uniform Contract and Specifications will submit its final report at this meeting.

Our Committee on Compulsory Legislation has been active during the year, assisted by individual committees and members in the different states, and will no doubt be able to report substantial progress since the last annual meeting.

Our Committee on Standards will possibly have some additions to offer to its last year's report, and I trust that by another year we will be able to devote a certain amount of the funds of the society to be used by the Committee on Tests in making such tests as it may decide on, the reports of which tests will be of value to the society.

The proceedings for 1897 were delayed in order to include a report of the summer meeting; they have now been completed, and have been sent forward to the members entitled to them.

The impression has been created that because a number of papers presented at the meetings of the society related to the construction of fans and blowers and the installation of these systems that we as a society were only in favor of mechanical means for procuring ventilation. I wish to correct this impression, and to say that as a society we do not endorse any system or method to the exclusion of any other. We ask that certain results be obtained, whether it be by steam, hot water, hot air, electricity, natural or mechanical means, and we number in our ranks the exponents of all of these systems and some who use different systems to meet different conditions or requirements.

It has been stated that because the question of heating related more to personal comfort than to health that we should not ask that the heating of buildings be regulated or enforced by legislation. I believe that heating is more of a necessity than a luxury in this country, and that it is wrong to compel children and others to occupy buildings that are improperly or imperfectly heated; and while I am a strong believer in and advocate of good ventilation, I believe that heating and ventilation should go hand in hand, and that when a public building is insufficiently heated it should be condemned until remedied, in the same way that we would ask the state governments to act in regard to buildings having insufficient and imperfect or defective ventilation. I say this, believing that a large amount of

sickness and death, particularly amongst children, is due to buildings which they occupy not being properly or unformly heated.

The secretary, Mr. H. M. Swetland, submitted the following report:

REPORT OF THE SECRETARY.

At the beginning of the year the society had a membership of 102 full members, nine associates and five juniors. Of this number four have resigned, two died and four dropped from the roll for non-payment of dues. There have been added by election thirty-one full members, two associates and three juniors, making a total membership of all classes of 142, an increase of 20 per cent.

The dues of the society have been so well kept up that there is a surplus in the treasury, as will appear from the treasurer's report. There is, also, a balance of unpaid dues amounting to about $600. The reason for this arrearage is doubtless a delay in sending out statements, and the failure perhaps of some members to appreciate the importance of prompt remittance. A committee has been appointed to push the payments of dues so that the society will undoubtedly be in condition to meet all demands as promptly as has always been the case in the past.

The number of papers on our programme is no greater than last year, and the topics for discussion rather less, but the subjects are of great practical, as well as theoretical, interest, and cannot fail to be of exceptional value to heating engineers and contractors everywhere.

Too late for action the question has been raised of the advantage to the society of holding its meetings at some hotel, rather than in these rooms. I think the hotel would prove by far the more satisfactory. Here we hold our formal meetings, listen to the papers, participate in the public discussion and then pretty generally disperse. I attend a great many conventions and society meetings in the course of every year, and observe that an important feature is the informal talk between individual members or such little groups as chance to gather about the hotels in which such meetings are held. I should expect to see this true in a marked degree in connection with this society. Many of its members meet each other rarely, if at all, except at the society's meetings, and such occasions should afford opportunity for the fullest and freest discussion of the countless little points important to all, but much more likely to come up in off-hand talk than to be brought out by the most carefully prepared programme of papers and topics.

The thought has also been suggested whether we would not profit

by the establishment of quarters of our own with a library, a secretary, etc. In my acquaintance with other similar organizations I have seen many instances where the expense of such an undertaking has proved so burdensome as to react seriously upon the society's prosperity. I think it would be unwise for us to consider such a step at this time. On the contrary, the holding of our meetings at a hotel would give us the privilege of assembly rooms without expense and the money thus saved could be applied with excellent effect to the wants of the Committee on Tests, or some similar purpose.

The treasurer, Mr. J. A. Goodrich, submitted the following report, which was read by the secretary:

REPORT OF THE TREASURER.

Cash on hand Jan. 26, '97, as per last report		$176.28
Cash received since that date.		
Initiation fees and dues	$1,089.25	
L. H. Hart fund	20.00	1,109.25
		$1,285.53
Disbursements		958.18
Balance on hand in Washington Trust Co		$327.35

There are no unpaid bills in the hands of the treasurer, except one for $10.14, which is submitted herewith.

The receipts for the year have been larger than they were for the previous year, and the disbursements have been less, leaving a balance in the treasury of nearly double the amount shown last year.

Respectfully submitted,

J. A. GOODRICH, Treas.

The President: Next is the report of the Chairman of the Board of Managers.

Mr. Wadsworth read the following report of the Board of Managers:

REPORT OF BOARD OF MANAGERS.

During the past year, which has been one of pleasing growth, your Board of Managers has had ten full quorum meetings, besides several which were of an informal nature, owing to a lack of a quorum, so that the interests of the society have not been allowed to suffer in any way for lack of proper attention. Each member of the board at all accessible to New York city has given freely of his

time, and the affairs of the society have been conducted on a business basis. As will probably be indicated in your treasurer's report, there is still a large sum due the society for members' dues, which are amply sufficient to meet the requirements of the society's work. The amount of outstanding indebtedness is comparatively small, so that we may be said to be in a fairly flourishing condition financially. To our membership we have added nearly twenty-five per cent.; there have been several resignations, and a few have been dropped from the roll, so that our present membership numbers about 142. Indications point to a large increase of applications for this year, so that this number will undoubtedly be greatly augmented.

Certificates of membership have been engraved and distributed during the year to those who were entitled to them by payment of dues, certificates for new members being prepared as soon as they qualified.

The experiment of having a semi-annual meeting last year indicated its practicability and value as a means of keeping interest alive and holding it. Your Board of Managers is therefore in favor of a summer meeting under conditions as favorable as those which made our first one possible and successful. The matter should perhaps be left in the hands of the incoming Board of Managers with power to act.

The publication of the transactions of our third annual meeting was, for various reasons, somewhat delayed, but hereafter the proceedings of our annual meeting will not be held in order to receive the report of any semi-annual meetings that may be decided upon. In this connection it may be said that the early completion of the work was made impossible by failure of some of the members to make the necessary revision of their remarks before publication, even on special request to give the matter attention. The clerk of the board, to whom was entrusted the work of getting out the report of the last meeting, would also call attention to the impossibility, when papers come in at the last moment, as was the case this year, of presenting printed copies of the papers to the members sufficiently in advance of the meeting to permit the preparation of discussion. He would also respectfully suggest that in order to overcome this difficulty those members who contemplate the presentation of papers at our meetings should begin the preparation of their prospective papers at an early day. He would also suggest that members who have not the time to devote to the preparation of a complete paper should send the data which may have been col-

lected by them to the secretary and let the latter present it to the society.

The papers which will be read at this meeting should elicit complete discussion of the subject treated, and if the society is to make material progress on engineering lines no data which are necessary to a full exposition of the topics taken up should be withheld.

Special attention is directed to the recommendations made by your president in his address, and all of them, in the opinion of your Board of Managers, should have favorable consideration.

The report of the Council was read by Mr. B. F. Stangland, as follows:

REPORT OF COUNCIL.

Looking backward upon what has been accomplished by our society during the past year the members of your Council feel some degree of gratification over the progress made, especially in so far as their efforts have contributed to it. During the year as many meetings have been held as were deemed necessary for the proper disposal of applications for membership, and such other business as should properly come before the Council. The fact that the judgment of the Council, as expressed in the action taken on applications, has been well received would seem to indicate that the work of that body has been satisfactorily done. Where application blanks were not so filled in as to warrant favorable consideration for the grade of membership for which application was made the applicant was requested in every such case to furnish further details, the final decision being based upon the additional information thus obtained.

The number of applications for membership made during the past year was greater than at any previous time, which is an indication of an interest in our transactions, a recognition of the character and aims of our organization, that gives promise of rapid future progress and development. Our influence as a society is unquestionably a growing one, and it will continue to flourish if each member will devote more time than in the past to the promotion of the best interests of the society in doing what he can to secure the accomplishment of the aims and objects of the society as laid down in our Constitution in the fourth section of the first article.

The co-operation of some of the heating and ventilating engineers of this and other countries is yet to be secured, but the members of your Council feel that it is simply a matter of time when the majority, if not all, of them will have joined this organization; and when it is called to mind that our profession, while not a new one, is, scientifically speaking, practically in its infancy, our growth can-

not but be regarded as highly satisfactory, in fact unprecedented when the available field is considered. Not only are the members of this society deeply interested in its work, but outside interest has been often manifested during the year by the inquiries made regarding our proceedings and by requests from colleges and other scientific institutions to be placed on our mailing list free. For the present, at least, the members of your Council deem it wise that these requests be granted, but it would seem that such institutions as can should return the courtesy thus extended by furnishing this society with the results of tests undertaken in the interest of the science with which our transactions deal.

The unqualified success of last year's midsummer meeting leads your Council to recommend that a similar meeting be held this year, provided the expense for such a meeting can be kept within as narrow limits as last year. This is deemed possible in view of the fact that accommodations for such a meeting in the way of a suitable hall could be had at some of the hotels in the city practically without cost. Papers for such a meeting can readily be secured, and in some cases assurances of a willingness to contribute matter of interest have been made. Then, again, the more often we meet the greater will be the educational benefit received by the public at large and the greater will be the amount of valuable data evolved. In this connection it may be said that the educational value of such an organization as ours cannot be overestimated. Our society is looked up to as being composed of men who are capable of teaching others, not necessarily the whole science of heating and ventilation, but each member is believed to possess some valuable information as to that branch of heating and ventilation of which he has made a specialty. This sentiment may best be expressed, perhaps, by the presentation of the following extract from some of our correspondence: "In the proper sense of the term, as nearly as I understand it, I am a mechanic. My work has been practical and my experience has been varied. I make application for membership, but, knowing as I do that the ventilation of public buildings should be given more attention and that laws should be enacted and enforced, I want some assurance of being upheld in endeavoring to make our public officers do right toward the rising generation. I look upon the matter in the light of a humanitarian. I do not expect to make any money out of being a member, but I wish to be a full member in order that I may have all the rights that others have, that I may be free to demand from the society the knowledge that I may require. I wish to be backed up in doing right by a class of men who know that they are right. I also have a son who is now taking quite an

interest in heating and ventilation to whom your transactions would be of benefit."

As to the class of professional men who have made application for membership little need be said, except that they have met all the requirements, since each member has received confidential circulars which have given the information upon which the Council has acted. Members could hardly have failed to note that men of extended practical as well as technical training applied for membership during the year. Among those whose applications were acted favorably upon the following have been elected by letter ballot, there being still further a list of some fifteen names, the result of the vote on which has been determined this morning and which follows the first list given:

MEMBERS ELECTED DURING 1897.

J. A. Almiral, New York; R. E. Atkinson, Leicester, Eng.; R. P. Bolton, New York; S. M. Green, Holyoke, Mass.; S. C. Smith, Buffalo, N. Y.; N. S. Thompson, Washington, D. C.; C. Wadsworth, Brooklyn, N. Y.; E. T. Weymouth, New York; Robert Campbell, New York; changes in grade of membership, Frank K. Chew, New York, from associate to full member; William H. McKiever, New York, from junior to full member.

MEMBERS ELECTED AT FOURTH ANNUAL MEETING.

G. E. Adams, Glens Falls, N. Y.; J. S. Farrell, Indianapolis, Ind.; C. G. Folsom, South Bend, Ind.; J. W. Gifford, Attleboro, Mass.; J. A. Gorton, New York; S. G. Neiler, Chicago, Ill.; G. O'Hanlon, New York; H. C. Meyer, Jr., M.E., New York; F. H. O'Neill, Philadelphia, Pa.; O. Schlemmer, Cincinnati, O.; E. P. Sparrow, M.E., Malden, Mass.; W. H. Switzer, Little Falls, N. Y.; W. S. Washburn, Brockton, Mass.; associate, H. A. Smith, New York; junior, H. H. Ritter, New York.

The president then called for the report of the Committee on Compulsory Legislation.

REPORT OF THE COMMITTEE ON COMPULSORY LEGISLATION.

Mr. B. Harold Carpenter: We report progress in the matter. We cannot report that any state has adopted compulsory laws. The states of New York, Pennsylvania and New Jersey are probably taking the most active part in the matter, and bills have been drawn up in all three states and presented. In the state of Pennsylvania it was too late to get it passed. I will read a letter which explains itself. I sent Mr. A. M. Sloan a copy of the bill which was drawn

up by Mr. S. A. Jellett at Mr. Sloan's request, and asked him if any changes had been made. He writes:

"I am in receipt of your favor of the 12th inst. enclosing copy of the act submitted to the last Legislature for passage. In reply beg to say that the copy of the act came too late in the session; that the House would receive no more new bills, and we were obliged to introduce it in the Senate. But there were so many bills on the calendar that it was simply impossible to get a hearing on it, and we were obliged to permit it to be killed in the committee. There were no changes made, because we intend to make the necessary changes on the various readings of the bill. I think at the time we had no definite changes decided on. I intend to bring the matter up on the convening of our next Legislature, and I would be pleased if your society would have a committee from Pennsylvania appointed to assist in procuring the necessary hearing before that committee."

A letter just received by Mr. Andrus, who was the Special Committee for the State of New York, from Senator Wray, of New York, explains the position in New York:

"My Dear Mr. Andrus:—I regret very much my inability to attend the meeting of your society, but my work here requires my presence in Albany. On the 13th inst. they introduced in the Senate the ventilating bill drawn and introduced by me last year, and succeeded in having it ordered to a third reading and referred to the Committee on Judiciary, of which I am vice-chairman." (This letter was dated the 24th of January. The other was also in January.) "On last Wednesday we had a very spirited discussion over the bill in committee, and it was finally laid over for further consideration. Senator Crum, of Schoharie county, and Senator Bracket, of Saratoga county, are the only Senators who opposed it in the committee. Their opposition was to the application of the act to incorporated villages. It may be necessary for a committee of one or more to appear before the Judiciary Committee to urge the passage of the bill; but we are trying to have it reported without this if possible. The bill was introduced in the Assembly by Assemblyman Marshall on January 20, and referred to the Committee on Affairs of Cities, of which he is chairman. I beg to suggest that your society adopt some resolution as to the necessity or desirability of legislation on this subject, and also that each member address a letter to his Senator and Assemblyman urging interest and assistance in the work of securing the passage of a bill of this character. It would be better to agree on the form of the bill which is most desired or which seems to me easiest of passage. The main thing to bear in mind, of course, is the advisability of having the requirement of ventilation a fixed principle of our state law, and when a law is once passed embodying that principle it will be a much easier matter to perfect it.

"Very truly yours,

"ALBERT A. WRAY."

I have under date of March 22 a letter from Toronto in reply to an inquiry that I sent regarding a meeting there. The letter says:

"Dear Sir:—I enclose you herewith copy of the report of the Committee on Ventilation made at the last meeting of the Provincial Board of Health of Ontario. Trusting that it may be of interest to you, I have the honor to be

"Your obedient servant,

"J. H. Beyo, Secretary."

The report enclosed is quite lengthy, and it goes into several tests. I do not believe that you would want to hear it all read here. They are taking some interest in this subject there also.

Mr. Swetland: Have they a compulsory law there.

Mr. Carpenter: No, I think not. I think they are working about the same as we are—trying to get some law passed.

The President: Do you think you will have anything further to present during the course of the meeting?

Mr. Carpenter: No; I think that I shall have nothing further, unless there is something from the committee.

The President: We will pass on to the report of the Committee on Uniform Contract and Specifications. Mr. Jellett is chairman of that committee.

REPORT OF THE COMMITTEE ON UNIFORM CONTRACT AND SPECIFICATIONS.

Mr. Jellett: With reference to the matter of uniform contract and specifications, our committee have been corresponding during the past year, and they have made no modifications of the report of last year. We have a conference to-morrow afternoon with the Executive Committee of the National Association of Master Steam Fitters, and we would ask that the complete report be deferred until after that conference, as it is felt that with the Master Steam Fitters' Association and ourselves agreed on a form of contract and conditions governing specifications, we are in much better position to go to the National Institute of Architects. We have had some correspondence with the National Institute of Architects through their secretary, Mr. Alfred Stone, of Providence, and he has criticised the proposed contract and conditions from the architect's standpoint, which is what we asked him to do, and he states that when the matter is in a definite shape on which we can agree, he will be glad to submit it to the Executive Committee of the National Institute of Architects for their action. He is of the opinion that the uniform contract prepared by the Builders' Association and the Institute of Architects does not fully cover heating and ventilation, and

thinks that a separate contract where the work is laid apart from the building contract might have some advantages. He is so far interested that he is willing to bring the matter up at the proper time and in the proper way for consideration; but he would like us to reach a definite conclusion on our part first so as to facilitate the progress of the correspondence. I would ask that the matter stand over until after this meeting which is to take place at four o'clock to-morrow afternoon, when we will know what the action of the Master Steam Fitters' Association is likely to be.

At the session on Thursday Mr. Jellett reported further as follows:

Mr. Jellett: I would report for the Committee on Uniform Contract and Specifications that our committee met with the Executive Committee of the Master Steam Fitters' Association yesterday afternoon. We had a session of some two hours and discussed the proposed form of contract from a number of points of view. It was decided finally that the Master Steam Fitters' Executive Committee should prepare a contract from the contractor's point of view entirely, first, as a basis of discussion on that end of the line. Then we should take the contract which we had prepared, with an outline of the general conditions, and the two committees should come together again, considering the whole matter from the contractor's point of view, from the engineer's point of view and from the owner's point of view; and out of those two papers it was hoped that a form could be adopted that would meet with general approval. When a form is adopted it was intended that it should be sent to the Institute of Architects for their consideration. That is the result of the work done so far; the new committee, to take the place of our existing committee, should take up that work with the Master Steam Fitters' Executive Committee at an early day.

On motion of Mr. Wolfe the report was accepted.

The report of the Committee on Standards was read by the secretary as follows:

REPORT OF THE COMMITTEE ON STANDARDS.

With a view of obtaining information in regard to the heating and ventilating of schools in the United States, the Committee on Standards in the fall of 1896 sent about 150 postal cards, with paid reply cards, to different towns and cities with a request that answers be given to five questions that were asked in regard to the schools. The questions were:

1. What system of heating and ventilating is used?

2. How many cubic feet of air are supplied per hour per pupil?

3. How many cubic feet of space are provided in rooms per pupil?

4. How many square feet of floor surface are provided in rooms per pupil?

5. What is the maximum number of children allowed in a room?

A card was sent to each of the principal cities and towns in this country, and the committee expected not less than one hundred answers, and from these they hoped to get information that would be of value to the society. In this, however, they were much disappointed, as but thirty-four answers were received. That is, scarcely one-fourth of the cards sent out were answered.

The names of the cities and towns from which answers were received, together with the answers to the various questions, are tabulated in the accompanying table. (See pages 22 and 23.)

From the answers to the first question it is learned that all kinds of systems of heating and ventilating are used, from the stove to the most modern system. Steam is used a great deal, and hot water but little. In only eleven of the thirty-four towns do they use a fan system of heating and ventilating, and even in these, the fan system is not used in all of the schools. There are very few of the cities or towns in which the furnace is not used in some of the schools.

The cards from sixteen towns do not have an answer to the question, "How many cubic feet of air are supplied per hour per pupil," and the answers from the others show that 1,200 cubic feet of air are supplied per hour per pupil in one town; 1,500 in three; 1,800 in ten; 2,000 in one; from 1,000 to 2,000 in one; from 1,200 to 2,400 in one, and from nothing to 2,500 in one.

Of the thirty-four cards received, twenty-nine have an answer to the question, "How many cubic feet of space are provided in rooms per pupil." And these answers show that 175 cubic feet or less are provided in three towns; between 175 and 200 in eight; between 200 and 225 in three; between 225 and 250 in eight, and more than 250 in three. In the schools of one town the cubic feet of space varies from 180 to 300; and in another it is said to vary from 300 to 500, although this is probably a mistake.

Thirty cards have an answer to the question, "How many square feet of floor surface are provided in rooms per pupil." Ten square feet or less are provided in three towns; between 10 and 15 in four; between 15 and 20 in twenty-one; and more than 20 in but one. In one town the floor space provided per pupil varies in the different schools from 15 to 25 square feet.

The replies on the thirty-one cards having an answer to the question, "What is the maximum number of children allowed in a room,"

show that the maximum number is 40 or less in two towns; between 40 and 50 in eighteen; between 50 and 60 in eight; between 60 and 70 in two, and between 70 and 80 in one.

Two of the towns are unable to supply any information on account of the lack of data.

The committee feels very much chagrined at the small number of replies received, as it may be considered as an evidence of the little interest in the matter of heating and ventilating schools that is taken by those who have the care and control of the schools in the various towns and cities in the United States. The questions which the committee asked were but few in number and would have required but little trouble or work to answer. And the answers would have been of more value to the various school authorities than to either the committee or this society. It was to be expected, of course, that no answer would be received from some towns, and that the authorities in others would be unable, on account of lack of data, to answer the questions; but that only twenty-five per cent. of the cards would be answered was not expected at all. And as the committee considers that the data to be obtained from answers to the questions asked from one hundred or one hundred and twenty-five cities or towns would be valuable not only to the society, but to all who have an interest in the sanitary construction of our schools, it, therefore, recommends:

That the Committee on Standards for 1898 be authorized to spend the money necessary to send to not exceeding one hundred and fifty towns or cities, from which answers have not already been obtained, cards, with paid replies, asking the same questions asked by the present committee. It will be noticed that it is not asked that the Committee on Standards for 1898 be required to continue the work begun by the present committee, but simply that it be authorized to spend the small amount of money that is necessary to carry on the work should it consider such continuation desirable.

Respectfully submitted,

J. H. Kinealy,

Hugh J. Barron.

GENERAL BUSINESS.

The President: The next order is the appointment of tellers. I will appoint as tellers Mr. J. G. Sorgen, Chicago; Mr. A. P. Fowler, Philadelphia, and Mr. N. P. Andrus, of New York. They will receive the ballots until three o'clock, at which time the ballot will close, and they will report at the first of the session this evening. New business is now in order. If there is no objection we will take

INFORMATION CONCERNING THE HEATING AND VENTILATION OF SCHOOLS IN DIFFERENT CITIES, COLLECTED BY THE COMMITTEE ON STANDARDS, A. S. H. & V. E., 1897.

Number.	City or Town.	Answers to Questions Asked on Card. 1.	2.	3.	4.	5.	Remarks.
1	Belleville, Ill.......	"Different systems; I cannot give you the names."	..	..	..	..	"For want of sufficient data I cannot fill above blanks."
2	Bismarck, N. D......	"No system."	..	..	..	..	
3	Bridgeport, Conn....	"Indirect steam"	1500	243	19¾	50	
4	Burlington, Iowa....	"We have several systems. Fan, indirect steam is the most popular."	1000 to 2000	180 to 300	16 to 20	65[1] to 70	"4 buildings have indirect steam with fans. 2 have direct steam, gravity ventilation. 2 have hot air. 4 have stoves."
5	Burlington, Vt	"Stoves, steam and warm air."	1800	200	16	50	"These figures are for the new buildings in which warmed air is used."
6	Davenport, Iowa	"Smead system and steam."	1800	195 to 200	15 to 18	50	
7	Detroit, Mich........	"A portion blower system and the balance hot air furnaces."	2000	226	17	..	"48 sittings in a school room, and 24 sittings in a recitation room."
8	Eau Claire, Wis. ..	"Indirect with fan. Hot air furnaces and stoves."	..	150 to 160	15 to 16	50	"High school has 300 pupils in one room at times.
9	Elmira, N. Y........	"The Smead."	1200	220	20	50[2]	"The above answers as to space are for rooms smaller than most of our school rooms."
10	Grand Rapids, Mich.	"Steam, direct and indirect, with natural draft; direct outflow."	1500	175	15	50	"18 buildings containing 214 rooms are steam heated. " 3 buildings containing 24 rooms have Smead system. " 7 buildings containing 26 rooms have hot air furnaces. " The last-named are in outlying districts and old buildings."
11	Harrisburg, Pa......	"Smead-Wills, Fuller & Warren, J. F. Pease, Hyatt & Smith; steam; stoves."	1200 to 2400	200	17	64	"The numbers given here vary with the different buildings and the system in use."
12	Jefferson City, Mo ..	"Heating by direct steam; ventilation by flues and windows."	..	216	12	50 to 60	
13	Macon, Ga....	....	..	286	20	40	"We have five heaters. Four are the Florida hot water system, and one steam heater."
14	Madison, Wis........	"Smead W. & V. Co."	1500	250	18	50 to 60	
15	Manchester, N. H...	"All kinds, from the best fan blower with aux. direct, clear down to the old cast-iron box stove for wood."	0 to 2500	300	24	50	"Several large grammar schools with direct steam heating and no ventilation. New high school about complete and I consider it up-to-date."
16	Memphis, Tenn......	"Ruttan and Hess dry closet system."	..	130	10	75	"Our high school is heated by an engine and ventilated by 'blowers.' Our system has given the School Board satisfaction."

17	Newport, R. I.	"Various."	..	233	20	50[3]	"No two school houses have the same system of heating and ventilating. Some are very bad; some are first-class."
18	New York, N. Y.	"Steam heated, and forced ventilation; plenum system."	1800	70[4] to 100	5[5] to 9	..	"The maximum number of children is figured according to answers Nos. 3 and 4. Size of class rooms about 24 ft. by 25 ft., 14 ft. high; laid out for single desks and seats and aisles on both sides; will hold about 60 seats of the Primary Dept. and about 50 of the Grammar Dept."
19	Olympia, Wash.	"Steam heat. Ventilating shafts from basement up."	..	300 to 500	15 to 25	..	"Four school houses in this place are well lighted, warmed and ventilated. Special attention is paid to these matters."
20	Omaha, Neb.	"Steam; hot air furnaces; fan. Holbrook & Kane systems."	1800	200	16	56	"This applies only to our new buildings, built since 1891. We have some buildings without any system of ventilating whatever."
21	Philadelphia, Pa.	"No system of heating adopted. The forced system of ventilation."	1800	200	15	50	
22	Quincy, Ill.	"The Haxton Steam Heating and Ventilation."	..	234	16½	50	"Three four-room buildings are warmed by stoves. In the others steam and hot air furnaces. One by steam and hot water."
23	Raleigh, N. C.	"No heating system. Ordinary stoves."	..	..	..	50	
24	Salt Lake City, Utah	"Steam heat: mechanical and natural ventilation."	1800	196	15½	55	"The hot air furnace heat and cremating closet systems have been removed this year and condemned."
25	San Francisco, Cal.	"Morgan."	1800	720[6]	20	50	
26	Santa Fe, New Mex.	"Coal stoves."	..	300	20	50	"We have 90 in one room; average 50 to room. No fixed number."
27	South Bend, Ind.	"Smead."	..	180	14	60	"In the new buildings the flushing closet system is used, and a fair system for heating."
28	Springfield, Ohio.	"Several kinds."	..	230[7]	8[8]	50	"These important matters have not received systematic treatment here. Steam is gradually crowding out hot air furnaces."
29	St. Joseph, Mo.	"The Smead-Westing Ventilating and Dry Closet Apparatus."	1800	240	20	60[9]	
30	Syracuse, N. Y.	"Steam and hot air. Mechanical and gravity."	1800	175 to 200	14¼ to 16	56	
31	Terre Haute, Ind.	"Steam, hot air and stoves."	..	244	18¾	40	"We are trying to keep the number down to 40, and are, as a rule, successful."
32	Wilmington, N. C.	"Hot water."	120[6]	168	16 to 18	48	"The larger rooms are for the older children and the smaller for the younger."
33	Worcester, Mass.	"Steam and furnaces. Gravity and blower."	1800	225	18	50	
34	Yankton, S. D.	"Smead."	..	..	..	50	

[1] Average is 47. [2] Seldom more than 40. [3] No fixed number. We try to keep the number below 50.

[4] 3 lower grades Primary, 70 cb. ft.; 3 higher grades Primary, 80 cb. ft.; 4 lower grades Grammar, 90 cb. ft.; 4 higher grades Grammar 100 cb. ft.

[5] 3 lower grades Primary, 5 sq. ft.; 3 higher grades Primary, 6 sq. ft.; 4 lower grades Grammar, 7 sq. ft.; 4 higher grades Grammar, 9 sq. ft.

[6] This is probably a mistake. [7] "Various, maximum 230." [8] "Maximum 8." [9] "Fifty is the average."

up the question of changes, additions and amendments to the Constitution. The first proposed change is in Article 2, Sections 2 and 3, to strike out the age limit. The present age limit of members is 27 years, and that of juniors is 23. It is desirable to strike out the age limit and leave the matter of age in both cases to the Council. That is the report of the committee.

Mr. Wolfe: In regard to that proposed amendment, I believe it covers the ground in the best way possible. I believe it is the intent of the society to assist and help all who wish to join us; but there are many who, we all know, are not entitled to full membership. If they are admitted to full membership and use our name they may bring the society into bad repute. There seems to be a feeling that men do not like to join as junior associates. So far as letting the bars down for full membership, I hardly think that is right, but we ought to admit all who want to begin and go on with us. I should favor the amendment on those lines.

Mr. Jellett: Mr. President, I move that Sections 2 and 3 of Article 2 be amended by omitting the reference to age limit, Article 2 of Section 2 to read as follows:

"A member shall be a heating or ventilating engineer or expert, or a mechanical, civil, electrical, mining, naval or military engineer, or an architect, who has been professionally engaged in the work of heating or ventilation for at least five years. Graduation from a school of engineering of recognized repute," etc.

Section 3 to read:

"To be eligible as a junior the candidate must have been actively engaged in the work of heating and ventilating for three years, or a graduate of a technical school of recognized repute with at least one year's active practice in heating and ventilating."

Mr. Jellett's motion was carried.

The President: The next proposed change is in connection with the meetings or duties of the Council. The recommendation of the committee reads:

Article 5, Section 1. To add to this section the words: "And they shall hold a regular meeting every two months."

Section 2. To add to this section the following: "They shall have full charge of all matters relating to the literary or scientific part of the society's work, and shall hold meetings every two months, or oftener if the affairs of the society so require. That the President and the Secretary be also members of the Council as well as of the Board of Managers by virtue of their office."

After a discussion by several members, Mr. Barron moved to pro-

ceed to vote on the amendment to the Constitution in reference to the Council.

The President: You understand that your vote on this motion is either to adopt or not to adopt the amendment.

The motion was carried.

The President: The next amendment is to change the time at which the Constitution can be amended. Article 10 to read: "This Constitution may be amended at any regular meeting of the Society, the proposed amendment having been submitted in writing to the Secretary, who shall send a copy of it to all the members at least sixty days previous to the date of the annual meeting."

Mr. Jellett: As I understand it, if this amendment is carried and we were to hold a semi-annual meeting this year, we could at such meeting amend the Constitution. I move that that amendment be adopted. (Seconded.)

The motion was carried.

The President: The next and last change is merely to correct an error in the by-laws in regard to members voting. The Constitution as originally made allowed members to vote. It still remains the same way, but a clause in regard to the voting says, "members and associates." It is merely the dropping of the word "associate" in Article 6. They cannot vote now under our present Constitution, but the Constitution is slightly misleading. Is there any motion in regard to that particular clause, that is, dropping the word associate under Article 6?

Mr. Swetland: I move that the word be dropped.

The motion was carried.

The morning session was then adjourned at 12.40 P. M.

SESSION OF TUESDAY AFTERNOON.

The meeting was called to order at 2.25 P. M.

The President announced that Mr. Hugo Ehrensberg, of Hamburg, Germany, was present, and requested that the members would extend to him all courtesies.

Papers were then read and discussed as follows:

A paper by Mr. George I. Rockwood, a member of the society, entitled "A New Type of Hot Blast Radiator."

A paper by Mr. John Gormly, member of the society on "Some Experiments on Steam Circulation."

After the reading and discussion of these papers discussions were had on the Topical Questions: No. 1. The rating of coils for hot

blast heating, and No. 3, Does the present-day competition protect good engineering?

A discussion took place on the advisability of having a committee report on the present methods of ventilating public schools in New York city. After considerable discussion and amendment of the original question, the motion was stated as follows:

The President: The amendment, as I understand it, is that a committee of three be appointed to visit one old hot air job and a steam job of the present day, and the original motion is that the committee visit an old installation and a present installation. Are you ready for the question?

Mr. Wolfe: I will say in regard to the motion as originally made, that I have had occasion to look at some plans of the New York city schools made by Mr. McMannis, and under the conditions of the buildings as they are constructed, with their glass partitions, I do not believe that there can be any better method put in a building. I have brought the matter up so that it might become a matter of record in this society, that in ten years, or you may say in five or six years almost—not through the efforts of this society, but that there are so many men in this country who have studied this subject—they can go before the public and say we have done what the doctors did not do. The doctors try to cure after a disease develops, but if a good system of ventilation is put in by competent engineers it is a preventive. The statistics of Massachusetts show that the introduction of a good system of ventilation has reduced the death rate in schools there in the proportion of 12 to 3. That puts our society on the standing of being a profession.

The amendment and the motion were carried, and the president appointed on the committee Mr. W. F. Wolfe, Mr. H. J. Barron and Mr. B. H. Carpenter.

The session adjourned at 5 P. M.

SESSION OF TUESDAY EVENING.

The meeting was called to order at 8.10 P. M.

The President announced that Mr. McNeil, of the New York Trade School, extends an invitation to any of the members and visiting guests who would like to visit the Trade Schools, First avenue, Sixty-seventh and Sixty-eighth streets. The report of the tellers was then presented by Mr. Sorgen as below:

We find fifty-nine votes cast. They were cast as follows:

For President:	Wiltsie F. Wolfe	38
	D. M. Quay	21
For 1st Vice-President:	J. H. Kinealy	36
	H. D. Crane	23
For 2d Vice-President:	A. E. Kenrick	36
	A. A. Cary	23
For 3d Vice-President:	John A. Fish	38
	J. J. Blackmore	21
For Secretary:	A. A. Jellett	29
	B. H. Carpenter	13
	C. Wadsworth	17
For Treasurer:	J. A. Goodrich	49
	L. B. Sherman	10
For Board of Managers:	W. M. Mackay	55
	F. A. Williams	43
	Thomas Barwick	35
	John A. Connolly	27
	A. C. Mott	27
	J. R. Wendover	23
	N. P. Andrus	23
	J. A. Langdon	23
	W. H. Clark	20
	George B. Cobb	16
For Council:	R. C. Carpenter	40
	W. S. Hadaway	36
	A. A. Cryer	35
	Henry Adams	34
	W. McMannis	31
	B. F. Stangland	30
	John Gormly	30
	W. H. Hill	27
	H. Eisert	16
	J. Hopson, Jr	16

The report is signed by J. B. Sorgen, A. H. Fowler and N. P. Andrus, Tellers.

The President: I would declare the following officers duly elected:

President, Wiltsie F. Wolfe.

First Vice-President, J. H. Kinealy.

Second Vice-President, A. E. Kenrick.

Third Vice-President, John A. Fish.

Secretary, A. A. Jellett.

Treasurer, J. A. Goodrich.

Board of Managers, W. M. Mackay, F. A. Williams, Thomas Barwick, John A. Connolly, A. C. Mott.

Council, R. C. Carpenter, W. S. Hadaway, A. A. Cryer, Henry Adams, W. McMannis.

Topic No. 2: "Under what conditions is it economical to use exhaust steam when such use creates back pressure?" was then taken up, and a written discussion was read by Mr. Rockwood.

Further discussion on this topic was postponed to a later session, and at the request of the president the first vice-president, Mr. Crane, took the chair and presided during the remainder of the evening session.

Prof. R. C. Carpenter presented a paper entitled, "A Test of the Heating and Ventilating Plant, New York State Veterinary College, Cornell University, Ithaca, N. Y." A long discussion by several members followed.

The session adjourned at 10.35 P. M.

SESSION OF WEDNESDAY MORNING, JANUARY 26.

The meeting was called to order by the President at 10:45 A. M.

The first paper on the programme was read by Mr. J. J. Blackmore. It was entitled, "Proportioning of Circulating Pipes for Steam and Hot Water Heating Systems." A long discussion followed.

The second paper, entitled "The Effect of the Heights of Walls on the Amounts of Heat Transmitted through Them," by Prof. J. H. Kinealy, was then read, in the absence of the author, by Mr. H. C. Meyer, Jr., and discussed at some length. New business was then taken up as below:

The President: We have received from the Senate chamber at Albany twelve copies of a bill that has been presented in our behalf at Albany. Some of the members from different states wish copies to take with them and we will distribute them as far as they will go. Mr. Harvey, I believe, wants two to take to Michigan with him.

We have received a number of letters of regret from our members and from prominent men in different sections of the country, who have been invited to be present at our meeting, but who have been unable to attend. It is not necessary to present them all at this time, but I would present one from the Chief of Police of Massachusetts.

Boston, Mass., Jan. 21, 1898.

W. M. Mackay, Esq., President American Society of Heating and Ventilating Engineers.

My Dear Sir:—Your esteemed favor of January 19 is received. To receive from you so cordial an invitation to visit and participate in the proceedings of your society at its annual convention is an honor which I appreciate more than words of mine can express.

For well I know that it is through the efforts of such a society you have organized that the people are educated to a higher knowledge of the importance of better sanitary provisions and better methods of ventilation in our homes and in places of public assemblage. To receive the endorsement of such men as comprise the membership of your society is indeed an honor that any man might well feel proud of. But not alone to me should be bestowed the praise. To those I have relied upon in the past, their constant and unwavering efforts to carry out and perfect those methods that have secured so good results in our Commonwealth, are due even greater praise than is due to me.

And what I am now to write is done with the deepest regret. To be obliged to say that I am unable to accept your kind invitation to be present.

At no time during the year do I find myself or the inspectors assigned to this scientific branch of the department so urgently called upon to make tests of the appliances which have been placed in our schools and other public buildings during preceding months for ventilation.

I take this opportunity to express my sincere thanks to you for your kind and encouraging words, and trust that in the near future I may enjoy the privileges and be honored by meeting you at your annual convention.

With the most earnest wishes for the success of your society, I am,

Very respectfully,

RUFUS R. WADE,

Chief Inspector of Factories,
Workshops and Public Buildings.

A paper by Mark Deans on "Single-Pipe Low-Pressure Steam-Heating Systems" was then read by Mr. Geo. I. Rockwood, and was discussed by several members.

The President: I will read a letter which has just been handed to me addressed to the American Society of Heating and Ventilation Engineers:

"Gentlemen: The National Association of Manufacturers; assembled in its third annual convention, extends to you a cordial greeting and invitation to attend the sessions.

"This association is interested in the promotion of the welfare of the industries of our country, and its work touches very closely many of the interests represented by your organization. In the belief that your members would be interested in the proceedings, and with a desire to afford them a more intimate knowledge of its work, we extend to them a cordial invitation to attend any of our sessions now being held in Masonic Hall, Twenty-third street and Sixth avenue. Very respectfully, Theo. P. Search, President."

The morning session then adjourned at 1 P. M.

SESSION OF WEDNESDAY AFTERNOON.

The meeting was called to order at 2.30 P. M.

The discussion of Mr. Dean's paper was resumed.

Topic No. 4 was then taken up for discussion. It was: "Does our society, as at present conducted, meet the objects of its organization as laid down in Article I of our Constitution?

Mr. Barron: I would like to hear from Mr. Rockwood on this subject.

Mr. Rockwood: I have not any doubt but that this is a valuable society. I do not know exactly how to describe the way in which it is valuable to us. I do not know that Section 4 of Article I does fully describe it. I should like to suggest certain amendments to the Constitution bearing upon this question. The whole of Section 4 seems very much spun out, and not particularly impressive or dignified as it stands. I think it might be modified and compressed, and I will read the modifications which I propose and then discuss it a little with your permission. My suggestion would be for an amendment as follows: Article I, Section 4—strike out the section as it stands and substitute for it:

The objects of the society shall be:

1. The promotion of the arts and sciences connected with the heating and ventilating of buildings.

2. The maintenance of a high professional standard among heating and ventilating engineers by means of the reading, discussion and publication of professional papers.

I think those two sentences comprise everything that is suggested in the previous section. It specifically covers in the first item the promotion of the arts and sciences connected with heating and ventilation, and the encouragement of goodfellowship among our members is to be taken for granted. We should not come together if it were not for that. The second clause of the section as it now stands says the object of the society is to seek "improvement in the mechanical construction of the various apparatus used for heating and ventilation." How can we promote the arts and sciences connected with the heating and ventilation of buildings without improving the machinery used for that purpose? So that is also superfluous. To quote again from the present section: The third clause says: "The maintenance of a high professional standard among heating and ventilating engineers." I have embodied that in my second proposition.

The fourth clause says: "To establish a clearly defined minimum standard of heating and ventilation for all classes of buildings." That

is a desirable thing to have, but it does not enter into the subject matter of a constitution properly. It is something for us, having formed a society, to debate and investigate and write papers upon and appoint committees to establish.

The sixth clause says: "To encourage legislation favorable to improvement in the arts of heating and ventilation, and to oppose legislation inimical to the business of the engineer." That is manifestly included in the promotion of the arts and sciences connected with heating and ventilation.

The eighth clause says: "To establish a uniform scale of prices for all professional services." That is to be taken as matter of course. Every engineering society has that as one of its objects, and it is a fit subject for debate by the society representing engineers as a body, but it need not be put in the constitution. I would like,by your leave, to suggest some further changes to the constitution, not, I assure you, in an iconoclastic but in a helpful spirit.

Section 5. "Fifteen members at any meeting shall constitute a quorum." It should, of course, say any regular meeting, because snapshot meetings and changes of officers are thus prevented. No radical legislation of the society can occur without due notice to the members if the word "regular" is inserted.

I have a further suggestion, one which relates to the duties of the Secretary, the Council and the Board of Managers. Article V, Section 2, says: "There shall be a Council, to consist of five members, who shall investigate and pass upon the eligibility of all candidates for membership, and have charge of the reading and publication of all papers." They have, you see, two functions—to pass upon candidates and to have charge of papers. As it seems desirable in the eyes of many to have a Council distinct from the Board of Managers, I do not see that there is any radical objection to such an organization and do not oppose it. I submit that the duties and responsibilities of the Council in connection with our Transactions ought to be more precisely stated. Reference is made to some of these duties in Article 7: "The reading of papers shall be under the supervision of the Council. Papers to be read at any meeting shall be submitted to the Council thirty days in advance, and shall be printed and distributed to the members one week before the meeting." This, with the other clause in Section 2 of Article 5, that the Council shall have charge of the reading and publication of all papers, is all that is said in the constitution about the duties of the Secretary and the duties of the Council with reference to the Transactions. I would like to propose these amendments:

"Article 5, Section 2. There shall be a Council, to consist of five

members, who shall investigate and pass upon the eligibility of all candidates for membership. They shall receive all papers contributed, and shall decide upon which papers or parts of papers shall be presented at the professional meetings of the society. They shall see that all editorial revisions of the proceedings, papers, discussions and reports are made, and shall decide what part of the same shall be published in the proceedings of the society."

I propose a new section under Article 5:

"Section 3. Papers which are to be read at any meeting shall be submitted to the Council thirty days in advance, and if possible shall be printed and distributed to the members one week before the meeting or earlier."

That simply is Article 7 brought into Article 5. Inasmuch as the two subjects are related they should not be separated by intervening articles. One otherwise might think that Article 5 covered the ground.

Where reference is made in Article 8 to the duties of the secretary I propose that this reference be omitted entirely and the following substituted:

"The duties of the secretary shall be such as usually pertain to his office. He shall have sole possession of papers between the time of their acceptance by the Council and their reading, together with the drawings illustrating the same."

That is the extent of my suggestions. I think that they should be distributed to the members before any action is taken, and I should also like to hear them discussed.

Mr. Barron: I would like Mr. Rockwood to go a little farther into a general criticism of the society. Of course his motive and his aim, and the motive and aim of everybody so far as they have thought of the matter, is to put us on the same plane as the mining engineers or civil engineers or the new Society of Naval Engineers, on the plane that those societies occupy in other countries and in this country. But I think if Mr. Rockwood would give us a general criticism of what we have done and tell us what he thinks will be necessary for us to put us as far as possible on that plane, it will do a great deal towards getting us there.

Mr. Rockwood: I think it would be highly improper for me to do as Mr. Barron suggests, for several reasons. I have no criticism to make of the society. I made some criticisms yesterday bearing upon the Transactions. I think the Transactions are exceedingly poor in their editorial management. My suggested amendments are put forward solely with the idea of correcting this defect in the future, and placing definitely the responsibility for editing the discus-

sions. I think the papers read here are equal to those read before any other engineering society. It simply requires, in order to maintain the dignity of the society hereafter and to give what we say in our printed proceedings a little weight, that the editing of the discussions should be done in a decent and tolerable manner instead of in the careless way it has been done.

The President: Is there any further discussion on this topic? The question is: "Does our society, as at present conducted, meet the objects of its organization as laid down in Article I of our Constitution?"—not how can we amend the constitution so as to improve the society, but has it been conducted so as to fulfill those objects stated in the constitution.

Mr. Rockwood: The society is conducted according to the Constitution. I think the constituion may be improved quite a good deal, and so far as it can be improved I think we are not conducting the society in a manner to thoroughly fulfill the objects for which it was organized.

The President: The only question that comes to my mind is this: We changed our constitution yesterday, and it seems to me we would have to dispose of the matter at this time by a motion. We would have to put the secretary to the expense of sending these amendments to the members before they can be acted on at the next meeting.

The reason that the word "regular" was left out in Section 5 was that the annual meeting was the only meeting at which we could elect officers. The summer meeting was not exactly an informal meeting, but was limited as regards the powers of the members at that time.

Mr. Jellett: I think under the provision made yesterday any member can suggest any amendment he chooses and send it in to the secretary, and we are required by the change made yesterday to submit it to the members and have a vote on that. We must submit it sixty days in advance to give them a chance to think it over. I suggested this topic for discussion, but I do not care to discuss it. I wanted to learn something. I wanted to hear the criticisms of all the members. I personally do not think the society has done as much as it ought to. That is as far as I go. I suggested that topic with the idea of having the various members say wherein they think it has failed, because by getting that information we hope that during the coming year we can improve.

Mr. Barron: The society has failed in one thing, and that thing no man can suggest a remedy for. It has failed in getting in a number of distinguished heating and ventilating engineers. They

amount to a large number. If we had them here this society would be as perfect as it would be possible for a society to be. No man can suggest a remedy for such a thing. At the present time these men are more or less in touch with us in an indirect way, and all we can do is to wait patiently until such time as all who should be here do come here.

Mr. Jellett: I do not agree with Mr. Barron. I think just as soon as we get the society to a point where it is to a man's interest to come in he will come. How to get the society to that point is what I want to find out.

Mr. Rockwood: I have a thought on my mind which I haven't given expression to heretofore. It would operate, it seems to me, in my radical way of looking at things, to bring in the other engineers whom Mr. Barron refers to. Is it possible that the name of this society suggests a society of very limited scope? Now there is a term which we might use to describe ourselves. I think almost every man in the room could call himself a building engineer as well as he could call himself a heating and a ventilating engineer. He has to put in power plants occasionally. I am sure Mr. Jellett has done enough of it, and very likely he is the consulting engineer of the building in all matters where the architect does not take possession. Now it seems to me that we should include in this society all the functions of a building engineer. We should have the sanitary engineers here, we should have the heating and ventilating engineers here, and we should have the steam men here, of whatever stripe they are. No man could be a consulting engineer of heating and ventilation alone, and make both ends meet if he relied on that solely. If we want to be a national society of engineers, ought we not to enlarge the scope of the society in some way?

Mr. Barron: I have always realized that our title is entirely too Germanic—it is too long. If our society could cover in some way just what Mr. Rockwood says, I am sure that would be a great advantage to us. The modern architects coming from our colleges are largely, if not entirely, engineers. If we could attract that class we could attract also mechanical engineers. In that way our society would possibly have a membership of 500, and yet only be a subordinate class of the large branch of mechanical engineers. Of course we cannot ever be a general engineering society in any sense of the word. We are simply a special engineering society. The electrical engineers, the naval engineers, the heating engineers are all branches of the general branch of mechanical engineers or civil engineers. It is all more or less a branch of the parent form of general engineering.

The President: I would like to remind Mr. Barron, also Mr.

Rockwood and the rest of the members, that every point in this constitution was taken up by an able body of men, many of whom stood high in other engineering societies, and from the name down everything was threshed out and a good deal of time and thought was given to it. I think the committee spent over a month on it, and it was then taken up piece by piece by the society as first organized, and the society spent a whole afternoon in getting the constitution in shape, the name and everything else. Of course, we do not claim that it is perfect; but it is a question whether we can brush it up and make it look any better.

Mr. Harvey: It seems to me, if you are going to make the society what its name implies, and there is not any question about the fact that there is lots of room in this country for that, instead of trying to do everything and get everything, if you get a few things you will do better. I think it is a great mistake simply to get quantity without quality. There is no end of room for the uses of this society. When we talk about bringing in builders we can then go on to the plumbers, and there is no limit to what we can get in the way of numbers. But I think it would be a good thing to draw the line about where it was when we started.

Mr. Rockwood: I appreciate the truth of what you say, Mr. President, and that is what makes me diffident about making the suggestions and offering the amendments which precipitated this discussion. At the same time, the world progresses, and as we get experience we change our views. That learned body of men who drew up the constitution did, perhaps, what no single person in the room could do—they formed the starting point, they got people agreed that far. It might have been a series of compromises, for all that I know. Nevertheless, whatever it was it was a human instrument, and quite as likely to be defective as perfect. In the second place, referring to Mr. Harvey's remarks, I do not want him to get the idea that I want the plumbers and the foremen and the builders to come in here and talk about their daily duties. It is not that at all. I suggest that we wish to broaden our minds when we come to this society. We wish to broaden our minds in the direction of heating and ventilation. In order to do that we have got to come in contact professionally with other men who are associated with us in carrying out heating and ventilation. Now, who are they? They are architects, sanitary engineers, heating and ventilating engineers, power plant men, etc. We wish to have a definite object for this society, and it seems to me if it involves the engineering of buildings it is definite enough. We need not go into the engineering of street railroads or canals or printing presses. We can go into the engineer-

ing of buildings; and if we did go into the engineering of buildings we would no doubt hear the architect's point of view of heating and ventilating, and we should hear what he has to say about the relation of heating and ventilating to sanitary arrangements, etc. I think that the scope of the society would be narrow enough as "Building Engineers," especially if we are going to call it the "American Society." I do not think we wish to belittle heating and ventilating. But it is through recognizing that it is a great subject that we increase the scope of the society to deal with it. Now what I have said may be inappropriate or impossible. It is for you to say.

Mr. Connolly: I think our name is all right. We have had a very interesting meeting this time. We have had interesting papers, and we have had discussions that range from Cincinnati to New York, from Chicago to Worcester, and we had yesterday a gentleman from Hamburg. Last year we had one from Stockholm. We have a representative from San Francisco, and I think the scope of the society is all right. I think we should not proceed with too much celerity. I think we are growing in the proper way. I think that ten years from now we will be a wonderful society, and without any change in the name at all; and after all that has been said, I think if we let well enough alone and go ahead as we have been going for the last three or four years we will be all right. I see three bound volumes on the President's desk, and I am free to say there is more information in those three volumes on heating and ventilation than in all the books published in the last hundred years, and I do not see that there is anything the matter with the society.

Mr. Kent: I do not often find myself in disagreement with my friend, Mr. Rockwood. He and I pull very well together in the Mechanical Engineers' Society. But I am entirely on the side of the gentleman who has just spoken in regard to the name. The only objection I have to the name is that the word ventilating is rather long to write. The words "building engineers" would not express the idea at all. We would have to consider pneumatic foundations, steel structure and architecture and everything in buildings, and we would not be the society that we are now and that we ought to be. The tendency of the age is entirely in the direction of specializing the engineering societies. The American Society of Civil Engineers, the oldest society, wanted to make itself the great engineering society of the country, the same as the British Institution is, which has 6,000 members. But it was found in 1871 that it did not pay enough attention to mining, so there was a mining engineers' society formed. In 1878 or 1880 a lot of civil engineers, members of the parent society, found that there was not enough attention paid

to mechanical engineering, so they formed the mechanical engineers' society. The mechanical engineers' society did not pay enough attention to electricity, so the electrical engineers' society was formed. So all these great societies were formed and no one of them paid enough attention to heating and ventilation, so there was a necessity for the establishment of this society of heating and ventilating engineers. The reason I want to belong to this society is that it attends strictly to that subject of heating and ventilation. I do not want to come here to hear about foundations and architecture, except as they have relation to heating and ventilation; so I think the name of the society is entirely right. The general subject of engineering is amply provided for outside of New York City by the local engineering societies. There are probably a dozen or twenty in different cities of the country, and if a man wants to make himself heard in his local society he can speak of any branch of engineering he pleases. But a heating and ventilating engineers' society is a necessity of the age to-day, and we will do best by sticking close to heating and ventilating and nothing else. The society will grow. There is no use in trying to hurry it, except by the perseverance of members who meet friends and say: "Why don't you come in?"

Mr. Rockwood: I agree with Mr. Kent in everything he has said. I do not think "building engineers" is an especially good term to use. I only mentioned that to put forward the idea. I did not even propose an amendment. I want to see gathered in the society all the men who have anything to do with heating and ventilating—contractors, architects, engineers and all others; only let them deal with the subject from the standpoint of engineering purely and simply. I do not think "building engineers" is a good term, neither do I think "heating and ventilation" is a good term. We ought to know all that there is to be known about drain pipes and the arrangement of drain pipes, and we find that out from the man who is conversant with drain pipes; and that man ought to know about heating and ventilating.

The President: It was the hope of the retiring officers that this topic would be fully discussed by the members as a guide for the incoming officers, to perfect the society along the lines on which it is intended to work, and I hope that no member present will fail to express himself if he has any suggestions to offer that will help matters in any way.

Topic No. 8 was then taken up for discussion. It is:

"Do the results obtained from the use of thermostats justify the cost of their installation?"

Topic No. 9 was then taken up and discussed. It read:

"What size reducing valve is required to deliver the steam to fill a 10 inch pipe at one pound pressure, the steam being reduced from eight pounds to one pound?"

The President then called for the report of the committee appointed to inspect some of the New York city schools. It was read by Mr. Connolly, as follows:

REPORT OF A COMMITTEE APPOINTED TO VISIT SOME NEW YORK CITY SCHOOLS.

New York, January 26, 1898.

Mr. President and Gentlemen:—Your committee appointed yesterday to visit certain schools in this city, to report as to the advance in the art of warming and ventilation, beg to submit the following for the consideration of the society:

Assisted by Mr. Connolly, at our request, to aid us, we visited an old building, probably constructed and erected at least 20 years ago. The method for warming is by direct steam heat, and excepting in several rooms hereinafter mentioned, no attempt to supply fresh air or exhaust the vitiated air exists.

In the kindergarten room an open fire-place showed the amount of air being exhausted from the room as 89 cubic feet per minute; the room had been occupied but a short time, the window was open, and consequently the air was in fairly good condition as to purity. One class room having been in session about an hour, with the windows open at the top, was in a condition that was nauseating and unhealthy to the utmost extent; in fact, the committee would state that this was the foulest school-room, as to air, ever visited by them. Other class rooms visited had either been flushed by opening all windows for a period of about ten minutes, or were being flushed while we visited them, or were unoccupied during recess, and were being flushed as stated. In each case, however, we beg to report that no attempt at ventilation was shown in any of them, and under the same conditions would have shown practically the same foulness of atmosphere as existed in the first class-room referred to.

In the two assembly halls, we found eight semi-direct radiators, introducing a total air supply of about 1,000 cubic feet of fresh air per minute—the number of occupants provided for in each room being 164, and even the limited air supply mentioned was lost through ventilating registers located on the side-walls near the ceiling line, consequently carrying the fresh warmed air away, without it being possible to circulate throughout the room.

The condition of this building can best be described in the exact language of one of the teachers, who informed us "That with the doors and windows closed for an hour and a half it would be utterly impossible to occupy the room and continue the school work."

The second building visited was one of recent construction. In it we found a heating and ventilating plant rendered somewhat complicated owing probably to the architectural detail that had to be considered. The general principle used was partially a mechanical supply and partially a direct-indirect method, and a small portion direct.

In the basement are located three boilers, all horizontal tubular wrought iron, two low pressure, one high pressure. The high pressure was to supply power for operating the fan blowers and electric lighting for the building, and the two low pressure for heating purposes. The exhaust steam from the high pressure boilers after having been passed through a grease extractor, was used in connection with the general heating plant and the water from condensation all returned to the boiler by pumps or discharged in to the sewer at the janitor's option. The fans used are four in number, three disc and one the blower type.

The fresh air supply is drawn down from a point about thirty-five feet above the basement through two shafts and propelled by means of the fans over the heaters through galvanized iron ducts to risers, and thence to the school rooms.

The first floor of this building is devoted to play-rooms, etc. The second floor is heated and ventilated by the fan, and the third and fourth floors are heated by direct-indirect, and the vitiated air is exhausted by means of the exhaust fans in the attic. The coils are composed of cast iron extended surface, generally termed the regular indirect radiators.

The supply to these radiators is controlled by an automatic valve attachment, the thermostat being placed a few feet from the heater, and in the duct the thermostats were set at 70 degrees, and we found the temperature in the duct at this point registered just 70 degrees. This air was forced through the rising ducts and entering the rooms directly under the window, the register faces or screens being placed on the window sill, which are made wide for their accommodation. This prevents down-drafts from the window surface. As the air enters the room at a temperature somewhat less than 70 degrees a direct radiator is placed in each room, the valve of which is automatically controlled by the thermostat attachment.

Under this arrangement a positive air supply is being admitted at all times, the automatic valve controlling the temperature. Vitiated air is exhausted from the rooms through register faces placed in the

floor, on the inner wall of the rooms. The air so exhausted is drawn through ducts to exhaust fans in the attic.

The third and fourth floors are warmed and supplied with fresh air through direct-indirect radiators incased under the window sill with screens above, the air being taken in at the base of the radiator and drawn over the heating coils before it enters the room. The valve of each stack of the radiators was automatically controlled as heretofore explained. These rooms are connected by means of ducts to the exhaust fans as upon the second floor. The fans are run in pairs, one in the basement and its partner in the attic being run by one engine, the connection being a vertical shaft.

The boilers are supplied with modern attachments, shaking grates, etc., and constructed to burn about No. 2 buckwheat anthracite coal. The draft dampers in boilers are not automatically controlled.

We found in all rooms that the fresh air supply was automatically controlled, and consequently a positive volume was insured and an equitable temperature maintained.

The air in all the school rooms throughout the buildings was very good, and particularly so considering the crowded condition of the rooms. Some of the rooms were occupied by at least sixty-five scholars while (estimating 200 cubic feet of air space being proper for each scholar) there should not have been more than forty-five in the rooms.

We think, as a committee, that within the limited time that these investigations were made that it is conclusively shown by the above comparison that the necessities and benefits accruing from good warming and good ventilation is thoroughly appreciated by the Board of Education, that the schools are apace with modern ideas, and that the architect and the engineers have accomplished most excellent results. Respectfully submitted,

WILTSIE F. WOLFE, Chairman. HUGH J. BARRON,
B. H. CARPENTER, JNO. A. CONNOLLY.

DISCUSSION.

Mr. Northrop: I would like to ask if there was any information there as to the amount of air being supplied per occupant of the room in the last building described?

Mr. Barron: We had to go to this school without any authority whatever. Fortunately, the principal of the school was a doctor who was a friend of Mr. Carpenter's. We telephoned to the Board of Education for permission, which was readily granted. We did

not have more than 20 minutes to make the inspection, and we had no time to make any measurements or get anything like definite data.

That plant reflects the greatest credit, not only on the architect who designed the building, but also on the engineerr. It also reflects great credit on the contractors and constructors generally. The work is magnificent, and the apparatus, I think, is first-class in every respect.

A Member: I think it reflects great credit on the janitor, also, for in some of the buildings I have visited in which heating and ventilating apparatus has been placed I find that it is very much neglected. I had occasion to visit a building in Brooklyn a short while ago in which there are two fans, both of which were blowing air over coils for heating the building. In the summer-time they are supposed to cool the building; that is, to supply fresh air. I found in the summer-time those fans were shut down, and the people were complaining that the place was so hot they could not work. Some changes were made in this building some few years after it was put up and a dust-preventing screen was put in. This screen was put in over two years ago. Recently I found the screen there, and it was all rags and tatters. The fan was running and the air going through was pretty dirty. So much for the janitor. I visited the other place. The fan draws air over coils. It is placed in the basement of a hotel building in this city. It was supposed to supply fresh air to a medicated bath. I walked down in the cellar looking over the plant for other changes that had been made. I met an old fellow there. I said: "How are things?" He said: "So-so." I looked at the steam gauge. It was placed alongside of the reducing valve. I found 30 pounds on it. I said: "How are you carrying 30 pounds there?" He said: "Mr. Connolly told me to leave that valve open." He had the by-pass valve open, and heaven knows what pressure he had on the heating coil. I then opened the door of the cold air chamber and looked inside. I found my cold air nozzle covered up with packing and old sacks and everything else. The cold air was shut off. I said: "Do you ever run this fan?" He said: "Sometimes." I looked at the fresh air vertical flue, which I think had a damper. I found the dampers closed. I said: "What are they closed for?" He said: "Sure, Mike Connolly told me not to open them, to leave them all closed." I said: "When you run the fan where do you get your fresh air from?" The job had been a pretty good job when it was done; I will admit that; but by constant digging and kicking and something else they had worn a little hole

underneath the door to the cold air chamber. They had a nick which they had worked out from two inches to about two feet, and that is where they got the fresh air, right through the cellar, and with an open sewer running through the cellar. So much for the janitor.

The President: The topic is: How are the difficulties in the proper warming and ventilating of our public schools best met where steam systems are used. We would like to hear from Mr. McMannis.

Mr. McMannis: I did not come here to discuss this matter. I came with the expectation of hearing all these bright lights give their views. From my experience I find that the system I am adopting at the present time works very perfectly. At present our buildings being constructed have ample flues. The superintendent of school buildings has got the system of construction of flues in buildings down to a very fine point. He is now ready to introduce flues four or five feet square in each class-room, and a ventilating flue of the same dimensions. So far as the heating goes, we introduce the direct heating radiators into the room in sufficient numbers to heat the room independently of the ventilating system. Then we establish heating stacks in our cellars, or in the first floor, as the case may be, and through the fan system we introduce fresh air into a room at a temperature of 65 to 70 degrees. In moderate weather we shut off the direct system.

Mr. Stangland: It would seem that in every city of considerable size there is sometimes an awakening to the public school problem. Brooklyn had her awakening. I hold in my hand a little pamphlet that was issued by a man to whom it seems to me that a momument would not be any too good, and could not be too high. The struggles that this man went through to try to induce his colleagues to introduce mechanical ventilation into the schools of Brooklyn is something that seems to me worthy of notice. Mr. Hayden W. Wheeler, a merchant in Maiden Lane, a man who was called a crank on ventilation, succeeded in becoming a member of the Board of Education, and then he began the struggle, away back in 1881. He talked and talked, and finally he made up his mind that he would go at it in another manner and see if he could not shame them into it. He tried to show what was being done in this country and abroad, and he asked similar questions to those that are sent out by the committee whose report was read here yesterday. He asked them to show how Brooklyn compared with other cities, and then he showed them what Brooklyn had in the shape of square feet of floor surface and cubic feet of space. He found that the average of

all school rooms combined gave 6.57 square feet of floor space per pupil. The average of all schools gave 89 cubic feet of air space to each pupil. That was the condition found in Brooklyn. He sent out his circulars all over the United States and to England, France and Germany. He asked: "What difference do you allow between grammar and primary pupils, and how many feet for each pupil, etc.? Give your means of ventilation." To sum it up, he showed that Brooklyn had the lowest figure of any city in the United States excepting New York, which made an equally poor exhibit. He says: "Compare Brooklyn with London, Paris, Glasgow, Baltimore, Washington or Providence, and it will be seen that the accommodations for the children in our schools are far below the average." And he tried to lay down some rule. He tried to have some resolutions passed. He said there are about 90,000 children to-day, and 2,000 teachers, spending 4½ hours in school each school day for ten months of the year. He says: "Who can possibly estimate to what extent the laws of health are violated by compelling these 92,000 persons to breathe day by day an atmosphere surcharged to the extent of five, six or seven times the sum of carbonic acid that normal air contains, and superadded to this an equal amount of organic impurities? * * * Yet we have 400 rooms in a worse condition. If the above language applies to rooms giving each child 66 cubic feet of air, what must be said of 88 rooms in our schools containing from 24 to 50 feet of air per pupil? * * * French prisons provide 1,500 cubic air feet per man per hour. Assuming that we treat our children with two-thirds as much care for health as the French do their criminal classes, we should make each pupil an allowance of 1,000 cubic feet per hour. * * * How long would any member of this Board continue in health if compelled to work five hours daily on an allowance of less than a cubic yard of air to breathe, with 50 to 100 other occupants in the same room on the same allowance? It is a little less than a crime to permit it, and so far as my efforts or vote can go, either as a citizen or a member of this Board, the city of Brooklyn shall be the criminal if the means to improve the sanitary condition of our schools is withheld. If life and health are blessings, I believe there are thousands of children in the public schools to-day who would be blessed by being turned into the streets (bad as is the remedy) rather than being crowded together in poorly ventilated class rooms for five hours a day." I will just read a little extract to show to what extreme it was necessary to go in order to shame them into doing something. Finally he asked: "May I not ask each member of the Board to visit some of our over-seated school rooms while

the classes are in session (if they have not done so already) and judge for themselves if the statements I have made are overdrawn? And if these statements are correct, may I not claim your aid and support in applying the only practical remedy? I offer for adoption the following resolutions:

"First. Resolved, That after the passage of this resolution no schoolroom in any new building shall be so seated that it does not allow at least 14 square feet of floor space and 200 cubic feet of air space for each primary pupil, 16 feet and 225 cubic feet for each grammar grade pupil below the third grade, and 18 square feet and 250 cubic feet for each grammar grade pupil above the fourth grade.

"Second. Resolved, That after the passage of this resolution no school building shall be erected that does not provide outgo and income air flues of sufficient size and so planned as to insure a change of the whole air of each schoolroom in said building from three to six times per hour."

The foregoing was adopted by the Board of Education, January 22, 1884, upon the unanimous report of the Committee of School Houses. Then began the question of how the arrangement of this mechanical ventilation should take place. Of course, we know that there must be an engineer—and there was one. Thereby hangs a tale. This engineer proceeded to put in mechanical ventilation, and as I have looked at a few of the schools in the past few years, I find them about all of one class. You might term that class low pressure steam heating. Plans were introduced for low pressure steam heating, probably one or two boilers. The pressure of the boilers, I think, was up to about 15 pounds, and fans were run while there was steam on the boilers. I never found one of those fans running. And so far as I know, there is not a single high pressure job or any arrangement made for running these fans except when there is steam in the boiler up to 15 pounds. What is to be done under those conditions? It seems to me that this society, each individual member, could take some city where he lives, or an adjacent city, and tell us at the next meeting what they do. Let us hold them up. Let us see what they are doing. We have everything to gain for the country and we have nothing to lose. It seems to me this is the greatest good for the greatest number. I will ask you, Mr. Barwick, if you have ever found in the city of Brooklyn any arrangement made for running any but a few buildings other than by the system I tell you of?

Mr. Barwick: I will state that my connection with the Brooklyn schools dates back to 1885 and 1886. The first plans that we used were of the gravity type. They were small, but still they provided a

positive supply of air. The boilers were placed in the basement and so arranged that not over 15 pounds' pressure could be run, owing to an open water column carried a sufficient height so that in case they have ran above 15 pounds the steam would blow out; that is, would blow the water down below the level of the tubes, and the escape, of course, would prevent an overpressure on the boiler. At that time they used a vertical engine. About 1892 they adopted the blower type. They put in horizontal engines for running them. They still maintained the same pressure upon the boiler. I do not know why they do not run those fans during the warmer weather, unless it is the mere fact of trying to save fuel. I have not been through the schools very often during the warm weather. My time has been taken up chiefly with the inspection of plants that were being put up at the time I was with the contractor, so I have only seen those that were really in action. I invited Mr. Hayden W. Wheeler to attend this meeting. I would have liked to see him here because he has had a great deal of experience in that line, not only with the Board of Education of Brooklyn, but in other schools in the city of Brooklyn, and I think that he would make a very good honorary member for our society. I think that anyone would make a proposition to that effect after having heard what he stated in the paper that was read by Mr. Stangland, and from the facts that Mr. Kinealy spoke about in our first Transactions. He is a man who has given a great deal of his own personal time, and is entitled to some recognition from some society of this class.

Mr. Barron: I would like to ask Mr. Crane how the difficulties in regard to warming and ventilating schools are met in the West, if he will tell us.

Mr. Crane: I have not had much experience with school warming. In fact, I am situated in a city which is in that happy condition of affairs where they are using stoves in their school houses to a great extent. They do compromise it—they admit a little air under the stove, encasing it and then throwing it out into the room, and having some exit for the air. Since then there has been at attempt at some other system, but nothing that is positive. I had occasion, I think it was in 1895, to visit Chicago, and witnessed a test that was being made there upon a day in January when there was a gale blowing off the lakes. A gentleman who was interested in the subject of heating and ventilation asked me to a school on the south side that had a modern plant of heating, such as Mr. Waters described at the first meeting of our society, a fan plenum system, double pipe automatic arrangement, and in each room there was a recording thermometer placed which gave the

temperature of the room. As the gale struck the four rooms on the first and second floors, those recording thermometers actually showed a variation of only two degrees in temperature between the windward side and the leeward side of that house, which demonstrated to me the power of a ventilating system even against such odds as that job was working against. I said to myself, a job that will do that cannot be beaten by any other system that I know of. And I adhere to that practice right through my heating and ventilation. There was no double sash in connection with this Chicago school building, if my recollection serves me correctly. It was an ordinary building. I might say that the troubles that existed in Brooklyn are guarded against in Chicago. There they have a janitor. That janitor is a mechanic, and he has an assistant; and then in addition to that they have a man back of them who makes them show the record. If they do not do it they are discharged. I don't think you can combine a janitor and an engineer without giving that janitor an assistant.

Mr. Barwick: I think what Mr. Crane says is right. I do not think you can combine a janitor with an engineer altogether; although in New York they do make the janitor the engineer; some of them are licensed engineers. I know some of them that have been steam fitters. They are paid so much per building, and while their pay is large, I think they have to supply their own help in the matter of cleaning, and also attention to fires, etc. In Brooklyn, I think it is a similar system, or has been a similar system. The engineers, or janitors as they are called, are appointed by the heating and ventilating committee. There is a chief engineer with assistants, who looks after all the repairs, and also looks after the men to see that they do their duty. What their instructions are I don't know.

Mr. Stangland: The gentleman who visited this school spoke particularly of finding a janitor present and doing his duty, and I think Mr. McMannis can tell us how he gets that work out of the janitor. I think I noticed once a little scheme that he had devised, and I would like to hear from him on that.

Mr. McMannis: The janitors now appointed have to pass their examination at the civil service. They have necessarily to be mechanics, either steam fitters or machinists, and hold a second-class license as engineers; and after they are sent to the Board they have to pass an examination before their appointment is issued, and then they are re-licensed for whatever school they are assigned to. The class of janitors we are getting at the present time are good men. But the old class of janitors simply had to keep the low pressure

boilers running. Before they were appointed, before they received their license or permit, they were sent to the school of instruction, and in that way they were enabled to pass their examination, and for some time after they took charge of the engines I sent my assistants around and gave them instructions and kept watch of them. Some of them made fairly good engineers in the course of time. But there are very few of those janitors at the present time in charge of high pressure plants. There are only about half a dozen in the whole system, and they are very bright fellows and get along very nicely. Previous to their passing the civil service they had to pass a very rigid examination which was gotten up by the Superintendent of School Buildings and myself. And if they succeeded in passing that examination they would get their permit and be licensed by the Police Board. At the present time we are getting in a very bright class of men as janitors, and those men are getting very big pay in our modern buildings, all the way from $3,000 to $4,000 a year. They have a great responsibility and a great expense. They have to hire all the help, both men and women, for cleaning purposes, and they have to keep those buildings in perfect condition. The buildings are visited by inspectors appointed by the Mayor. There are about 135 inspectors at the present time in the city, and each of those inspectors has a certain number of schools to investigate and see if they are kept in proper janitorial condition in every respect. In case they find the school is not in perfect order they report it to the Superintendent of School Buildings, and they are summoned before the Building Committee and receive a reprimand, probably once or twice, and the third time they are either assigned to a smaller school or else dismissed from the service. That is the system that has been adopted, and I think it will be the means of getting a first-class set of janitors in the system.

Mr. Wolfe: Through the country, in the smaller class of school buildings, they use the furnace system to a considerable extent, and the furnace system gets more black eyes from the janitor than anything else. Every school board recognizes that there is in a steam boiler an element of danger. Consequently they will employ a janitor of ordinary intelligence. Now I will give you a little personal experience as the kind of janitors that we have to contend with in furnace work. We had a contract to do a certain school in a certain town in Massachusetts, where the air supply must be in accordance with the law. We gave them a job that was right. When the cold weather set in we had a telegram to come immediately—that nothing was working. I went down; I could not get the ash pit door of the furnace open on account of the ashes that

were on the basement floor in front of it. I feel perfectly safe in saying that the furnace firepot had not been cleaned out in six weeks; all the fire there was, was in a little circle of about 12 inches in diameter, and I could not get the thing going until I had shoveled out the ashes. The ash pit was practically full to the grate; hardly enough air going through to give combustion to what little coal I could get on the top. The janitor was a colored man. He said he was 90 years old. I do not believe that, but I think he was 80 beyond question. I said to him: "I don't want to make any trouble for you, but the thing is right here: this apparatus is put in here by us and we cannot afford to have our reputation suffer by your negligence, and if you don't take better care of it in accordance with directions I propose to report you to the Board." He told me, with all proper emphasis, that the sooner I got there the better he would like it. He said: "I take care of three schools in this town. The greatest distance between the two is a trifle over two miles. I am supposed to care for the three schools, keep them warm, shovel the snow from the sidewalks in the winter, do the sweeping and the cleaning, and I get a dollar a week." (Laughter.) That is true. That town is Great Barrington, Massachusetts. They paid him a dollar a week for doing that. He said: "I don't care anything about what you tell them; I can't live on a dollar a week; and I spend some of my time in taking care of furnaces in people's houses, and I cut the grass in the summer and do things like that. I don't care anything about their schools. They simply keep me because they can't get anyone else who will have anything to do with them." I put that just as strong to the Board of Education as I am putting it to you, and they thought they were liberal when they raised that man's pay to $3 a week. That is the sort of thing we meet. Now these same men, had there been a steam boiler in the building, would have recognized the element of danger and they would have kept a man there to watch it. There is where the furnaces get hurt to the greatest extent.

Mr. Barron: I think we all know that in Boston, New York and Chicago the heating and ventilating systems in the schools are practically as perfect as can be expected to-day, but there is one large city in which the conditions are awful. That is the city of Philadelphia. I would like Mr. Gormly to tell us what he knows about the conditions of the problem given here, that is, "How are the difficulties in the proper warming and ventilating of our public schools best met where steam systems are used?"—where such systems are used in the city of Philadelphia.

Mr. Gormly: Mr. President, I am sorry I cannot say much for

the city of Philadelphia in relation to her schools. Our schools at the present time are greatly crowded. Many of the schools hold but one session in the morning for a certain class of students, and another session in the afternoon for another class, in order that all may have some schooling. But it is a crying evil with us, and it is well recognized by everyone in the city. The difficulty with us seems to be that our town is ridden entirely by a class of politicians. They do just what they please, and when it comes to an election we are fools enough to elect the same men every time. If there is no money in it for the city councilman he doesn't care whether we have schools or not, nor how they are cared for. I know of my own personal knowledge where a party came to me and said that he had a lot for sale beside a schoolhouse. There was a movement made to have the school enlarged. This gentleman told me that one of the city councilmen came to him and said: "What is your lot worth that is beside such a school?" The owner of the lot said: "My lot is worth about $3,000." The building on it was not of much account. The councilman said: "If you will ask $30,000 for that lot the school will take it. I will see that we buy that lot for school purposes." The owner of the lot was an honest man, I believe, and he refused the offer. He said he would not do any such thing, and it was not long before the lot on the other side of the school was bought for school purposes at a very high price, practically the same price that the other man was told to ask for his lot if he wanted to make a sale. Those are the conditions we are working under in Philadelphia. We are politics-ridden, and our schools are not in a good condition. The modern schools we are building are being put up in pretty good shape, but the trouble is we haven't got enough of them, and there are parts of the city where we haven't half enough. Some effort is made to ventilate our schools. We have two classes of schools in our city, the public schools and the parochial schools. We have probably as many parochial schools as we have public schools. There is some effort made in the parochial schools to ventilate. But, so far as my experience goes, it is done by means of direct-indirect radiation and very little of the fan system is used. They place radiators under the windows and carry air in from the front through a screen under the radiator, passing it through the radiator to become heated and discharging it at the top of the radiator. They also, in connection with the system, have ventilating flues, which are practically aspirating shafts; are headed by a coil, or in some instances by a vertical pipe having steam and running from the base of the flue pretty well up in the flue. We do not pretend at all that our schools are models, or that they are what they should be.

Mr. Kent: I would ask Mr. Gormly if he does not think that the council be improved by being ventilated a little more in the papers?

Mr. Gormly: We have tried that, and they seem to be absolutely fireproof. We cannot do anything with them in that respect.

Mr. Barron: This subject of ventilating the council, I think, is a good one. Prof. Carpenter just now said we should agitate the subject a little, and Philadelphia is the place where it could be agitated. Mr. Onderdonk is one of our members and largely engaged in the ventilating business in Philadelphia, and Mr. Jellett is largely engaged there and there are other splendid engineers there, and yet this Board of Education has most antiquated methods. If you go there and bid on a heating apparatus you are at the mercy of a miserable little clique. There are such little cliques in many small country towns. People talk about how we are ridden in New York. I tell you that kind of a clique that runs that school system in Philadelphia would not be tolerated in New York for five minutes. I say that as a Philadelphian. I was brought up there.

Mr. B. H. Carpenter: I would like to have Mr. Barron specify what country towns he refers to. (Laughter.)

Mr. Barron: I except Pennsylvania country towns, and I particularly except Mr. Carpenter's town of Wilkes Barre. I had reference especially to Great Barrington, Massachusetts.

Mr. Wolfe: Great Barrington is straight, so far as the Board of Education is concerned. But when it comes to paying a dollar a week, that is a sample of their liberality.

Mr. B. H. Carpenter: I think it would do good if some of the people, probably, from Brooklyn and Philadelphia and other cities, could go out among the coal heavers in the anthracite coal region. Possibly we are a little slow, but we have some pretty good school boards. They do not give us enough money to put in the system as we would like it, but we are getting some pretty good systems, much on the plan of the one we visited to-day, and other fan systems which we guarantee to give 30 cubic feet of air per pupil in the room and keep it warm.

On motion of Mr. Stangland the meeting then adjourned until the following day.

MORNING SESSION OF THURSDAY, JANUARY 27.

The meeting was called to order at 11.10 A. M.

Mr. Connolly: Under the order of new business can I read a letter that has been presented this morning by request?

The President: It would be in order at this time.

Mr. Connolly: We have with us Mr. Joseph Wright, of the

Bennet Wright Company, of Toronto, this morning. He has received from Canada the following letter:

PUBLIC WORKS, CANADA,
CHIEF ARCHITECT'S OFFICE.
Ottawa, January 24, 1898.

Gentlemen:—The hot water heating practice of the department has been called in question by a firm, not hot water fitters themselves, which have made the statements (1) that the specifications issued by this department are 25 years behind the times and (2) that the pipe coils with cluster headers, wrought iron pipe bows and wall stays are inferior for circulation and heating purposes to cast iron radiators of the same nominal radiating surface. The questions I am asking you to favor me with an answer to are:

"1st. Do you consider the specification enclosed herein 25 years behind the age in hot water practice, and if not, what is your opinion of it?

"2d. Whether you consider cast iron radiators more or less efficient circulators and heaters than wrought iron coils with cluster headers, bows and wall stays, where both have equal radiating surface, or do you consider both equally good? The cost is not to be considered as a factor in this, merely the efficiency.

"If you consider the practice given in the specification enclosed either antiquated or objectionable, please state so. I would be glad to receive a copy of any specification you may consider superior, together with your remarks thereon.

"Other prominent experts are being asked, and as the department freely sends plans and specifications of heating apparatus to all responsible firms applying for same, I trust that none will consider it too much trouble to furnish the information required.

"I have the honor to be, your obedient servant,

"D. EWART, Chief Architect."

Mr. Joseph Wright,
The Bennet Wright Co.,
Toronto, Ont.

The President: I will ask you to read the clause in the specification referred to.

Mr. Connolly: It is a specification for hot water heating apparatus, Victoria, B. C., public building. Under coils it states as follows:

"Wall and ceiling coils are to have no cast iron fittings excepting couplings, and the headers next risers—all curves to be of bent pipe —bends at distal end to be of wrought iron pipe bent to semicircles—

coils to have ornamental cast iron hook plate standards resting on floor and secured at top to wall. Headers of circulations to be of ornamental patterns to be submitted to and approved of by department."

The President: I would state that Mr. Wright, of Toronto, Canada, is with us this morning as an invited guest of the society, and has the privilege of the floor. Is there any discussion of this letter?

Mr. Barron: I would like to hear from Mr. Wright and get at the base of this difficulty if there is any difficulty in the specification.

The President: We will be glad to hear from Mr. Wright. I would like to mention, according to the Constitution of our society, we endeavor to eliminate anything of an advertising nature from our proceedings, and I merely mention that as a word of caution. We will be glad to hear from Mr. Wright.

Mr. Wright: It affords me much pleasure to be with you this morning, but I am sorry to say I am not a good speaker. In regard to this letter, my experience in steam heating or hot water heating —take hot water heating with coils, so much dust and dirt accumulate around these box coils that it keeps the heat from getting out. They enclose these coils with cast iron ornamental screens. The dust is there sometimes half an inch thick, and you cannot get the heat out when it is coated with a fine dust from carpets and from rooms. I have taken coils out in rooms and I have put in cast iron radiators with 15 per cent. less heating surface. With the coils they had double ridges on. With 15 per cent. less heating surface they were able to heat the room just as well if not better. I had three cases of that. With cast iron radiators with the upright sections the dust falls off and keeps them a great deal cleaner. You can get at them and keep all this dust away. If the heaters are cast evenly, about a quarter of an inch thick, I think it is far superior to wrought iron pipe. In England they have some cast iron heaters. They are using an inch and a half. I think they ought to be good metal to hold heat.

Mr. Crane: I would like to ask the gentleman for a description of this coil. I ask it simply because the term as you apply it is not familiar to me.

Mr. Wright: It is a two header. (Mr. Wright made a sketch.) The top pipe comes to the bottom and the next pipe the same way. The return comes out of the bottom and the supply goes through the center. This is a solid casting, perhaps four and six pipes wide—eight pipes wide.

Mr. Crane: In this particular specification how are they to be covered?

Mr. Wright: They are to be covered as directed by the architects.

Mr. Crane: With a solid top?

Mr. Wright: There may be a marble top on it and there will be an iron screen or they may put panel work and put a little screen in at the top and bottom. In some places they will leave them open.

Mr. Crane: Admission of air at the bottom?

Mr. Wright: The air enters at the bottom and the heat goes out at the top.

A Member: How long are those coils?

Mr. Wright: Ten feet horizontal in some cases; in others 15. Sometimes they are only 5.

Mr. Kent: Does that represent four pipes in the vertical section?

Mr. Wright: This is three pipes wide and four are in each. Sometimes they are five high. Sometimes they are eight high.

A Member: What is the size of the pipe?

Mr. Wright: Inch wrought iron.

Mr. Kent: These are put against the wall?

Mr. Wright: Yes.

Mr. Kent: And there is never more than one set of heaters above the other?

Mr. Wright: Always one above the other, never two side by side. You see the heaters are made wide enough to take six, eight or ten of those pipes wide, making a regular box.

Mr. Dean: How much chance is there for air to get to and from the coil?

Mr. Wright: If they are open they can get all around the coil, but if they close them in, they sometimes have the whole front an open casting, an ornamental case; sometimes they put a wire screen.

Mr. Dean: The point I was getting at is, does not the marble top in the screen prevent the air materially from circulating freely in the pipes?

Mr. Wright: It does, and it helps to keep the dust and dirt there. I have seen them between these pipes so coated that you would think it impossible for the heat to get from the pipes.

Mr. Kent: I understood it might be made as much as six wide.

Mr. Wright: These would be made six wide. I have made them six wide.

Mr. Kent: At the risk of exposing my ignorance I think I will start the discussion by saying that this is twenty years behind the age. It is all wrong, I think. The cause is this: Where you have three pipes like that in a vertical row, you say these may be made six wide, there is not the same chance for the cold air to get in and cir-

culate all through these pipes, and the air surrounding these pipes is therefore hot; while if you have only a single row of pipes, cold air comes in on all sides and gets a full chance to wash the pipe. The trouble with this system is not that it is a wrought iron system against a cast iron system, but it is simply bunching a great mass within a space where the cold air does not get access to it, and then putting screens all around and still further check the air supply. The air may find a place to get in through the bottom without going through the coil.

Mr. Barron: I think your reasoning is entirely wrong, Mr. Kent. In the first place you have certain conditions existing in this particular problem. You have got to get your heating surface within 10 or 14 feet. Just as soon as you strike the problem actually you have to bunch your heating surface. You are right where you say if you make them six, eight, nine or ten wide—of course you can exaggerate and spoil the whole thing. But you have got to proportion properly either two or three. To start off and say positively that you must not have more than one—

Mr. Kent: I did not say that. The very best possible statement probably would be one. Two is possible, but still not quite as good. At three I think it becomes distinctly bad. The two may be pretty good.

Mr. Barron: In the particular case I think three would be about the correct thing. I think you would find that you would probably stop at either two or three.

Mr. Kent: No. I think the question is one of compromise. If you had only two we might have to have these coils so long that they would be bad looking. We compromise and say that we will make them short and put in three rather than put in two, and have them fifteen feet long.

Mr. Crane: I am inclined to differ with the gentleman somewhat. In the first place we get heat by convection. Now if you can arrange a coil of that character, so that every square foot of the surface will be exposed to air, relieving it at the top directly through a register if you choose, but being careful that the actual opening of that register is sufficient to carry the air that has been warmed away without any great friction, being careful again to permit of that coil being located sufficiently high from the floor to permit of a flow of the colder air, which we all know travels along the floor to the heating surface, then I cannot see why that radiator is not a better radiator than even any cast iron device that we have to-day, six feet long, assuming that it is that. The travel of the pipe is twelve, probably fourteen feet. A column of water passing through that is four-

teen feet, with the L's bent in the way that they are, if made upon the theory that the least friction is secured by making the bend eight times the diameter of the pipe, which I understand is admitted in hydraulics, then you certainly have reduced the friction of the passage of the water through that coil to a minimum. We are striving to get a circulation of water through our apparatus with the least amount of reduction of temperature—that is, within a certain limit. Therefore, I cannot see why that coil should be condemned as being twenty years behind the times. It certainly can be made to do what we are attempting in something that will look a great deal better. But if you take and house that coil in with marble tops and with ornamental screens at the sides, then you certainly affect its efficiency to a greater extent than we can calculate unless we have the drawing of the plans permitting of the distance between the top pipe and the coil and between the floor and the bottom of the coil. If we knew those factors we could tell probably what percentage we would be losing. There are features about a coil constructed in that way that are certainly very good in the matter of circulation of hot water. Those features of accumulation of dirt and dust are objectionable, I think, to such an extent that it would condemn the use of it from a sanitary point of view in any modern building.

Mr. Crane, at the request of the president, took the chair.

The President: I would like to say in connection with this subject that my earlier experience with hot water heating was largely or altogether with wrought iron pipe surfaces for radiation and arranged in the horizontal way that Mr. Wright has described—in that way and also with the return bends. The wall coils are altogether made in that way for government work, and the box coils are sometimes made that way and sometimes with the return bend. My experience has been both with the use of that and with the cast iron surface that has come on the market more recently than when that pipe coil surface was properly constructed of a large enough area so that they got a free circulation through all of it, and it was of efficient surface at all, from 15 to 20 per cent. more effective than the same amount of any cast iron section radiator. I have also taken the wide radiators, say four-section radiators, of cast iron form and have turned them over on their side and have obtained better results in heating from a four column radiator than from the same radiator set up the other way, and the conditions covering would be exactly the same in my opinion in a cast iron radiator or a wrought iron coil. If you put a screen and a marble top on a radiator you then reduce its efficiency as much as you would reduce the efficiency of a

coil. So with those conditions you are considering the coil under less favorable conditions than you are considering the radiator. It is not a fair comparison for you to take a coil and cluster it up and leave a radiator open. Of course the cast iron radiator is more in keeping with modern architecture and so is more generally used. But it is not fair to say that you should put a coil in a building and consider the efficiency of that coil covered up as compared with a radiator open.

The question of dirt and dust—I removed an apparatus some three years ago which had been in for fifteen years with steam. They were radiators of the vertical type. Below and above those radiators, under the screen tops, we had what resembled, as nearly as I can describe it, about an inch and a half or two inches of hair felt. It was nothing but the accumulation of the sweepings of that building. The parts of the radiators that could be got at were kept perfectly clear. I do not know that the owners of the building ever knew the condition of things until that radiator was removed. Now it reduced the efficiency of the inlet and the outlet of the air in exactly the same way as the screen or with the coil. But my experience from tests has been that a wrought iron pipe coil, horizontal, will do from 15 to 20 per cent. more effective work than a cast iron radiator under the same conditions. But if you take an inch pipe where you should take an inch and a quarter, you are not treating the subject properly. There is one point there that might be improved on in the construction of these coils. They carry the top heater so that they do away with the unequal flow at the inlet, and they go direct from the flow main to the opening of the top heater. I believe in hot water heating that we want to reduce the friction as much as possible, and my practice always was that both on the flow and on the return I went vertically into my coil instead of turning into an elbow. I wanted to correct what I thought would be a false impression that cast iron radiation of any construction is more efficient than wrought iron of equally good construction that is put under the same conditions.

Mr. Barron: Mr. President, I am very sorry that Mr. Crane should take the position he does, because it shows how difficult progress is. This form of radiator that Mr. Mackay has just described in such glowing terms in regard to its efficiency, which nobody denies and which he practically admits is not modern—in France and England they are using this old thing—that is, the unprogressive engineers are. There is no progressive engineer that will use a thing of that kind. They condemn it at once. They use it if they are compelled to as contractors. They will manufacture it if compelled

to. Why, if men's minds work in such channels progress is utterly impossible. The thing is abandoned by all progressive men in heating engineering. No one doubts its efficiency at all. If you fix up a direct-indirect radiator and shut off the heating surface more or less, of course the conditions of efficiency will be about the same. I do not think it is more efficient than the cast iron. I think for equal distribution of surface of the same commercial value of metal you get just as good results from cast iron. There is no question but that the modern cast iron radiator in infinitely superior. The cast iron radiator is away in advance. It represents a hundred years difference really in heating and ventilating. The difference in progress is really a hundred years between that form of radiator and the modern cast iron direct and indirect radiators. One form of an apparatus or mechanism is just as efficient as another, but which is the best to meet the conditions, not only from the engineering point of view and the economical point of view, but from the commercial point? What do the progressive engineers and manufacturers and contractors use? What is the best practice of the country or of the world? Of course the best practice in heating and ventilating is unquestionably here. Canada suffers from its English connections, and, of course, is governed largely by English ideas. The hot water coil or stack is away out of date, and I am exceedingly sorry that a gentleman from the progressive West should take that position.

The President: If it were a question of appearance alone then the cast iron radiator would be the most pleasing design to use. But the principal objection to this construction of coil is that it has been encased, and it has been said that if it was left open or if we could get at it and clean it it would do away with the chokage. But encased it is subject to this condition. My opinion is that cast iron radiation under the same conditions would be exactly the same. I use to-day perhaps 90 per cent. of cast iron surface, but if I were using indirect stacks or radiation below windows, or anything of that sort, it is just a question of whether I will put in pipe coil or cast iron radiator, which is not any more ornamental, not any more efficient and not any more in advance of the age. You take a low, wide radiator, put it behind a screen and put a marble top on it, and I cannot see that you increase the appearance or efficiency over what you do if you use a wrought iron pipe coil. In my indirect hot water work I have used largely pipe coils until the question of price prevented me from doing it. My only object in using cast iron sectional extended surface was because I could do the same amount of work for less money; but as for efficiency, which I believe we are all aiming at, I cannot see any object in using an ornamental cast iron radiator for

an indirect stack or for exactly the same use back of a screen. If it is only the appearance of the radiator, and you hide the appearance by the same old methods that were used thirty or forty or fifty years ago, I cannot see why we should use something that is not as efficient behind those screens. We are looking at the question of efficiency, and I contend that under the same conditions, the objections to the wrought iron pipe coil will exist in the cast iron radiator. The answer to the question of course is that with that construction open to the public I would be considered behind the age, but if it were encased in brick stacks or in metal stacks or behind registers there would be no mistake in using it.

Mr. Fowler: I have conducted some tests on a cast iron radiator with practically the same circulation as that, and found that we were able to produce in the preliminary tests that we have made 15 to 25 per cent. increased economy. The tests are about to be made now under authority, which will be very interesting to this body later on. But the tests that I have conducted have satisfied me beyond all peradventure that a cast iron radiator with practically that circulation can be made and present a pleasing appearance and get up very near to the efficiency of a pipe coil.

Mr. Kent: When I said I thought that system was twenty years behind the age, I did not think that the question was as to the relative efficiency of the cast iron radiator and the wrought iron coil. I think possibly Mr. Mackay may be right in stating that the wrought iron pipe has 15 per cent. more efficiency than a cast iron pipe of the same size. But this other gentleman may be right in his statement that cast iron may be more efficient. What I said in regard to the thing being twenty years behind the age was the thing as presented as a whole. That is, the pipes bunched together there, covered by a marble plate and hedged in by a screen. It is that whole construction taken together as a whole that I said was twenty years behind the age.

Mr. Barron: That is just exactly how my remarks would apply. I would like Mr. Wright specifically to state if he proposes to use a direct-indirect radiator in place of this, or if he proposes to take cast iron stacks and fix them up the same way. In other words, if his system is just as much out of date as this system that he condemns?

Mr. Wright: I might say I have nothing to do with this work at all; only I received the letter since I have been in New York. It was sent to me in Toronto and forwarded to me here, and I received it last night. It asks my opinion. I might say that I have done some of the government work, and the way I have told you is the way they have had it done.

Mr. Crane: I am going to make these remarks simply to correct the record and particularly the remark that Mr. Barron has made relative to the position that I have taken in the matter. I simply argued from the point of whether this coil as constructed was up to date as a circulator. Then I wound up my argument with the statement that for sanitary purposes it was not to be thought of for an instant. In other words that the accumulation of dirt that I have discovered in box coils where they are located in rooms is of such an extent that I believe it would affect sanitary conditions. But as a circulator I contend now that it is the proper system to be applied to hot water; that it admits all the water and transmits it through those surfaces and returns it to the system or to the generator in the most direct way with the least friction. That was the only point that I had made in the matter, and I had said this without any thought of a radiator that was constructed and upon the market that embodied the same idea. But since one of the speakers has referred to it, I now remember that there is one. I also have had in mind to call the attention of some of the manufacturers of radiators to exactly this fact. I do not believe that it is good practice to house any kind of a radiator or any kind of a coil, whether cast iron or wrought iron, so that you cannot get at it to clean. Therefore, I always use direct radiators in my practice of the cast iron type.

Mr. Hyde: I am not a member of the association, but would like to be granted the privilege of speaking. A gentleman asked the question if he is behind the age twenty years. It has been admitted here that as a circulating radiator the apparatus is not twenty years behind the age. I do not think we should send back any such word, when we admit that they are not twenty years behind the age. The wrong perpetrated there, from the sanitary point of view, is the encasing of it and the retaining of this dust that should have been distributed. Are there not some good qualities in keeping it there instead of distributing it among the children? The fact that it retains the dust there was a benefit to the children, and when the school was not occupied it could be blown out. I should judge that the circulation in that ought to be good. I should think there was a good sound principle of circulation in it. We ought not to send word back that it is twenty years behind the age when we admit that it is not.

Mr. Crane: I believe from the remarks that the society have made that this government official will find that we have simply intimated that we recommend it as a circulator and that it should not be housed; that if they are willing to accept such a homely arrangement as that is, we are perfectly willing that they should, upon the same principle that the man whose wife kissed the cow could not account for her taste.

Mr. Rockwood: Let us suppose that such a radiator as this were used in connection with a fan and that the air supplied to the fan were filtered so that the air moved across this radiator from the inside out again. Under such circumstances I do not see how it could ever become unsanitary. If it were out of sight I think very likely it would prove the most efficient form of radiator you could use for the money. At any rate it is one desirable form to use under such conditions. The discussion shows how various are the conditions under which radiators may be used.

Mr. Crane: I would call attention to the fact that we are discussing it as a direct radiator and as a hot water heater. If it was a steam radiator I might adopt that same system.

Mr. Rockwood: Can any radiator be a direct radiator which is enclosed?

Mr. Crane: Yes, it can be. It is simply against the wall with that marble top probably two or three inches from the pipe and there is where the dust accumulates. The current of air does not seem to carry it away.

Mr. Rockwood: How is air admitted to the radiator under those circumstances?

Mr. Crane: Just under the bottom, as air would be admitted to any direct radiator, passing along the lower strata until the radiator becomes hot and then finds its way out as fast as it can, and of course it deposits this fine lint, and the power of the draft not being sufficient to carry it away it is deposited on the pipe.

Mr. Kent: The screen is to hide its ugliness, that is all.

Mr. Barron: I assumed that it was a direct-indirect. I would like to ask Mr. Wright if they don't make this generally direct-indirect; that is, if they don't take air from the outside generally?

Mr. Wright: I have never seen the air taken from the outside.

Mr. Barron: They do abroad very generally. I was criticising that more as a direct-indirect form as compared with our modern form.

Mr. Wright: It is a direct heater, the air taken out of the room and circulated through the heater and back again.

Mr. Hyde: I did not suppose it was anything of that kind. I think he is a hundred years behind the age.

Mr. Wright: I might say where these coils are used we have a good deal of weather—15 and 20 and 26 below zero.

Mr. Hyde: Mr. President, I don't think people for all that want to go outdoors to get some fresh air, and if you bring them into a school it doesn't make any difference if it is 100 below zero, you have got to give them some air to breathe. If there is any place where

they have got to keep windows shut longer than they do there I would like to know where it is. If I was in that engineer's place I would not specify one of those, because we have got radiators that are in appearance a thousand per cent. better and are also as effective.

Mr. Wright: I might say that where these heaters are put in there they put double windows on and then calked the windows around with oakum to keep the fresh air from getting in.

The President: I do not know but that we are getting a little way from the discussion. I do not know that Mr. Wright would recommend that thing. It certainly is not as ornamental as a coil. Mr. Wright, would you advocate the admission of air in the same plane?

Mr. Wright: Oh, yes, I would. I am putting up buildings and changing the air every fifteen minutes. I just concluded a contract of $90,000, and we change the air in every room every fifteen minutes.

Mr. Connolly: What building is that?

Mr. Wright: The new municipal and county buildings in Toronto; and then in the Parliament Buildings, British Columbia, they are fitted up with direct-indirect heaters, and we bring the air from outside, as some gentlemen thought this was done. Our heater has got a fresh air pipe brought from the outside under the heater.

Mr. Barron: Six years ago I met Mr. Wright at the Boston meeting of the Master Steam Fitters' Association. At that time he was full of plenum ventilation and heating. I spent the best part of a day on an excursion with him. I think the only subject we talked about was hot blast heating. So that Mr. Wright is not just starting in on that field, and it is wrong to assume that the Canadians are very much behind, but they are a little—that is all.

Mr. Wright: If it be in order I might state that we fitted up in Toronto the Foresters' Building, an office building ten stories high. We have outblasts for ventilation and direct heating with Johnson's thermostat regulating the direct heaters. For summer time we have a refrigerating coil, putting in fresh, cold air, regulated by the Johnson heat regulator, to keep the temperature right in summer as well as winter.

Mr. Meyer: I would like to ask a question, and that is as to the relative durability of cast iron and wrought iron coils when used for hot water work, if anybody can give any information.

The President: I would like to say my experience in wrought iron pipes extends over 30 years, and I do not know of any wearing out in that time.

Mr. Crane: While we are on the subject I will make a drawing to

show you something that did happen. It consisted in an arrangement of boxed coils. I will tell you what another man said the reason was. There was a box coil with a wrought iron pipe, and return bend in that direction. (Illustrating by a sketch.) I think he put his bend there. That coil had an angle about like that and this end of it here gave way, this being perfectly free of all pit marks, while on this side of the coil it was full of pit marks, showing a destruction of the texture of the iron. That coil was in probably two or three seasons when it exhibited that phenomenon. That is the only time I ever met with it, and I have hopes that I will meet with it again in some other case so that I can look into it thoroughly.

Mr. Barron: One of our members, Mr. Tompkins, has had a little experience relative to the durability of wrought and cast iron for radiating surface, or at least he knows something about experience with them, and I would like him to tell us something about what he knows in that regard.

Mr. Tompkins: I have had considerable experience with cast iron radiators and a little with wrought iron. In regard to this radiator that has been discussed so thoroughly as a direct-indirect radiator, I should think it was rather behind the times. So far as its efficiency is concerned I believe it would be a good form, so far as the circulation of water is concerned. But there are many things in regard to cast iron radiators that might be said in their favor, and one thing is the form of construction.

So far as the question of durability is concerned, I think it would be in favor of the cast iron. So far as the durability of wrought iron is concerned I have nothing to say, for I think they all last long enough when they are used for steam heating, perhaps, or hot water. I do not know of any that have given out. I do not want to go into a discussion as to the relative merits between cast iron and wrought iron, because I have no data with me, although I have made a great many comparative experiments between wrought iron coils and cast iron coils and the dividing line, and the results of the experiments I won't attempt to give you. But I have data with respect to the different velocities. Take, for instance, fan work—the efficiency of the cast iron coil as against the wrought iron coil—a wrought iron surface of that form for fan work is very efficient. It is only a question as to what velocity you use.

Mr. Wright: In respect to the durability of coils and cast iron, I have had thirty years' experience. I have taken coils that have been 20 years in use, and they have been very good after 20 years' use. I have taken others that have been in 10 years, and they have been pitted right through with little pin holes. I found that if the castings were even they never gave any trouble.

The President: Did you find that pitting from the inside or outside of the wrought iron pipe? Was it due to the air on the outside or the action of the water on the inside?

Mr. Wright: It was from the inside. I never found it from the outside. It was always pitted from the inside.

Mr. Fowler: Some years ago I had a little experience which may give some light on this subject. I had occasion in Ohio to take out a boiler made of wrought iron pipes screwed into cast iron headers which had been in use 30 years, and I found that the threads on the wrought iron had entirely crumbled away. There was not any semblance of a thread left on the pipes where they were screwed into the headers. But the threads were perfect in the cast iron headers. This may give us some little light on the subject as to the comparative durability of wrought and cast iron.

Mr. Crane: Since the gentleman has spoken I recognize the boiler he has reference to. But that is probably not exactly germane to the subject, from the fact that there are other elements that would occasion that—probably the great amount of sulphur that we have in our coal. The subject, as I understand it, is as to the relative merits of cast iron and wrought iron for radiators. The facts of the case are, as I suppose we all know, that where boilers are located for heating water for large institutions and hotels in a very short time they become pitted. In one instance I had made a boiler that could either be heated with the fire or could be heated with a coil that was run to the steam for hot water purposes in a large institution. In about seven months after it was installed the end of the wrought iron tubes where they were riveted or upset on to the head gave way, about half of them. A test was made and the fault lay, as the experts claimed, in the fact that the plumber had not arranged a circulating system in this boiler, and the result of that fault was that acid had formed in the boiler and eaten away the wrought iron. The plumber who had constructed the job, probably one of the most careful that we have in our section of the country, called the attention of the owner to the fact that there was a circulating pipe that the engineer had taken out for a drain pipe, as it disappeared under the ground and had a valve in it. He had never opened it. The boiler was so pitted on the inside that you could not place your finger anywhere on the shell or head without coming in contact with a pit mark. The other tubes were in about the same condition, but claimed to be sufficiently strong to stand the test, and by our giving them a guarantee that it would be all right they accepted it from us. That has been going for seven years. I simply mention

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this to show you the results with wrought iron. I have had no experience with cast iron.

Mr. Rockwood: Mr. Crane touches the point of the matter when he refers to the lack of circulation as the cause of pitting in wrought iron. It is very frequently the same that boilers composed of mild steel will pit in some portions of them. It has been the experience of boiler men that the occurrence of such pitting has been due to lack of circulation in that portion of the boiler. By providing a positive circulation there the subsequent pitting has been prevented.

Mr. Fowler: It has been the practice for years to make heaters with a cast iron shell and a wrought iron coil inside of it. The inside of the cast iron shell would have the same action of the water passing through that heater that the coil would. But invariably we would find that the coil would have to be replaced three or four times, and still not outlast the life of the cast iron shell surrounding it, showing beyond doubt that whatever element goes in to destroy it attacks the wrought iron more freely; and that was the point I wish to make on this statement about the headers and a pipe screwed into them—that whatever element there was there which entered into the destruction of the joint attacks the wrought iron more easily, and accomplished the result quicker than it did on the cast iron.

Mr. Dean: I saw a direct cast iron radiator at one time set in a recess in a wall. My attention happened to be called to it in this way: It had 52 feet or 56 feet of surface, supplied with a one-inch pipe. The man said they were using altogether too large pipes; that a one-inch pipe would supply 52 feet, and do it so that it would be absolutely noiseless. But coming to look the matter up we found that the radiator was encased, just as this coil is, and that as a matter of fact the radiator was only doing about the duty of a 20-foot radiator. On the other hand I cannot help but think that the coil is considerably behind the times, because I cannot conceive of considering the coil separate from the screens. I think if any of the fitters in business in New York city should put in that coil without putting in a screen they would have a pretty hard time in collecting their money for the job.

Note by the Secretary*: The discussion in relation to the specifications for hot water heating issued by the chief architect's office of the Department of Public Works, Ottawa, Canada (see pages 51 to 62), seems to have been based, to a great extent, upon a misunderstanding of what kind of radiators were called for in the specifica-

* Added since the meeting.

tions. The following correspondence is placed on record in order to make the matter clear:

PUBLIC WORKS, CANADA,
CHIEF ARCHITECT'S OFFICE,
OTTAWA, February 2, 1898.

Dear Sir: I take the liberty of addressing you with reference to some discussion which took place Thursday, January 27, while you were in the chair at the meeting of the Heating and Ventilating Engineers, New York.

My information was gained from the report in "The Metal Worker" of January 29, page 37, from which I learn that Mr. Joseph Wright asked, on my behalf, for the opinion of the meeting as to the relative value of box coils with screen and marble slab covering, compared with cast iron radiators. While I would have been glad of the opinion of such a distinguished body of experts on the questions asked, I may say that the letter was written to Mr. Wright for his private opinion, and it contained no reference to box coils, covered or uncovered.

The coil referred to is the trombone coil, and I am enclosing you a copy of the original letter sent Mr. Wright, a copy of the specification and a drawing of the trombone coil, in order to acquaint you with the facts.

If you could find time, without much trouble, to give your opinion as to the relative efficiency of the coil referred to and the cast iron radiators, such would be highly appreciated.

Yours very truly,
D. EWART, Chief Architect.

William M. Mackay, Esq., 235 Water street, New York, U. S. A.

NEW YORK, February 7, 1898.

Mr. D. Ewart, Chief Arch., Public Works, Ottawa, Canada.

Dear Sir: I have your favor of the 2d inst., enclosing specification, plan of coil and copy of your letter to Mr. Wright, of Toronto. You do not get a full report of the discussion on your letter, which Mr. Wright submitted to the society, in "The Metal Worker." I gained the impression that he wanted us to condemn the coil and endorse cast iron radiators. I talked strongly against this myself, as did also Mr. H. D. Crane, of Cincinnati, Ohio, who has had a large experience with government work in this country, and who believed the coil to be the best construction. On receipt of your letter last Friday, there being a meeting of the Board of Managers and the council of our society, I took your letter and plan with me and sub-

mitted it to those parties, I being chairman of the Board of Managers, and it was the universal opinion of both of these bodies, composed of the leading men in our society, including three past presidents, that the coil as illustrated for hot water was thoroughly up to date and from 15 to 20 per cent. more efficient than any cast iron radiator; any statement to the contrary is possibly made by some one interested in the manufacture or sale of cast iron radiators. My practice has been to make this style of coil with two separate headers, frequently feeding into the bottom of each header by allowing the upper one to project beyond the lower one, and we in this country use a lock shield air valve instead of the wheel air valve which you show as per enclosed circular.

I shall be pleased to give you any further information in regard to our practice and our opinion of yours at any time, and take pleasure in saying that your coil and specification generally is fully up to present practice. I would suggest that you send a similar sketch, specification and letter to Mr. H. D. Crane, Cincinnati, Ohio, who has been president of the Master Steam and Hot Water Fitters' Association and has been vice-president of our society, getting his opinion which, I believe, will conform with mine and the other officers of the society, who are leading men in this line of business in this country. Respectfully, W. M. MACKAY.

CHIEF ARCHITECT'S OFFICE,
OTTAWA, February 9, 1898.

My Dear Sir: I have to acknowledge receipt of your favor of the 7th inst., on the relative efficiency of hot water circulation in coils and cast iron radiators, and to say that I am much obliged for your full and candid expression in this connection. I may add that all the replies to my letter fully bear out your statement that the coil "is from 15 to 20 per cent. more efficient than any cast iron radiator."

I am, my dear sir, yours, faithfully,

D. EWART, Chief Architect.

W. M. Mackay, Esq., Mfg. Royal Heaters, 235 Water street, New York city.

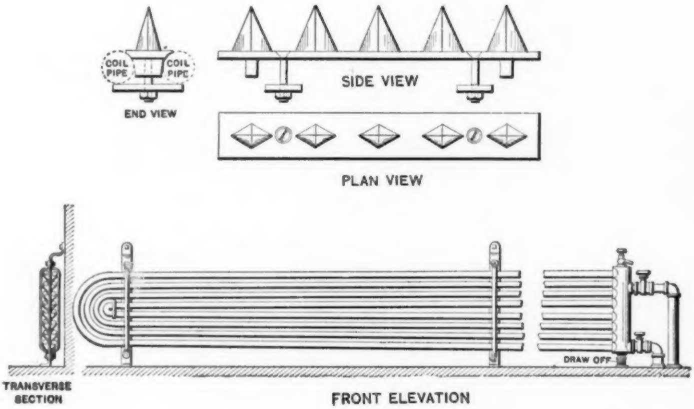
The drawing of the "Trombone" coil, referred to in Mr. Ewart's letter of February 2, is herein reproduced on a reduced scale, and the following are clauses of the specifications which refer to the coil:

Extracts from Specification for Hot Water Heating Apparatus, Public Building, Portage la Prairie, Man.

All pipes, fittings, etc., for apparatus, throughout, to be new and

of the best quality and of not less bore than figured on plans. Pipes to be wrought iron, of American steam-pipe standard weights and sizes, straight, true and round with full clean cut threads, those over 1¼ inches to be lap welded, tested to 500 pounds per square inch; of 1¼ inches and under, tested to 300 lbs. per square inch. After pipes are cut the burs on the inside must be carefully reamed out to give full bore.

All iron fittings to be cast, not malleable, to have full clean cut threads and be extra heavy. All pipe fittings to be eccentric and so arranged in complete work that in all pipes running horizontally, the upper inside line of the bore shall be straight and without dips or any departure from the horizontal except the grade of the pipe.



Reducing fittings are to be used in all cases instead of bushings—no bushing to be allowed.

All cast iron elbows in basement to be of the radius shown on drawings.

All connections of mains with branches, and of branches with coils, tank, etc., are to be so made that a free and continuous circulation of the water in the whole apparatus will be obtained at all times and under all circumstances, as should any defect arise in this particular the contractor will have to make any necessary alterations at his own cost.

Each coil on first and upper floor to have a ½-inch draw-off pipe with ½-inch globe-valve connected with drip-main in basement story, so arranged that each radiator or circulation may be separately emptied.

All coil connections to be made with right and left valves or couplings; no running joints, long threads or packed connections being permitted.

All coils, pipes, fittings and ironwork, to be freed from oil, rust, etc., by means of alkalies and sand-paper, and the surface of the iron left perfectly clean until painted or bronzed.

Heating surface to be as per plan, but it will be optional for this Department to reduce or diminish the quantity of heating surface in any of the coils or circulations so long as the total quantity asked for is not exceeded.

Wall coils are to have no cast-iron fittings excepting the headers next risers—bends at distal end to be of wrought-iron pipe bent to semicircles—circulations to have ornamental cast-iron hook plate standards resting on floor and secured at top to wall. Headers of coils to be of ornamental patterns to be submitted to and approved by the Department.

Figures accompanying coils give running feet of 1-inch pipe, independent of connections, return bends, etc.; deficit or excess in any one not to exceed 5 feet lineal of 1-inch pipe, but total quantity asked for to be supplied.

Coil protectors, as per drawing, the whole length of top tier of pipes in coils of public lobby, ground floor, are to be secured to the coils.

Each coil is to have an air-valve as per sample, and at inlet a gate-valve which is to be $\frac{3}{4}$-inch for those marked 80 and under, 1-inch for those over and up to 144, $1\frac{1}{4}$-inches for those over 144 and up to 200, and $1\frac{1}{2}$-inches for those circulations over 200. On first and attic floors each coil or wall circulation to have a valve on the outlet similar in all respects to that specified for inlet.

The President: Is there any further discussion on this topic? If not, we will proceed to the next paper on the programme, which is written by Mr. Frank Ashwell and edited by Mr. D. M. Nesbitt, a member of this society. It is entitled "English practice in the warming and ventilation of technical and art schools." I would ask Mr. Wadsworth, when the time comes, to read that paper.

Mr. Wolfe: I probably shall have the honor this afternoon of reporting the names of the several committees. It has been suggested to me, and I think wisely, that upon the committee regarding compulsory legislation it would be advisable to have representatives in such states as Illinois and Ohio—I don't know whether there is any in Pennsylvania—but in such states as are liable to take action in such a matter. To do this it will be necessary to enlarge the committee somewhat, or to pass a motion that would enable them to add an advisory committee, or by whatever name you might desig-

nate it, so as to enable us to have a committee that could act jointly with the committee on compulsory legislation. I bring this up for the consideration of the society and to hear their views upon the matter, and to know whether it meets their wishes or not.

Mr. B. H. Carpenter: Mr. President, I have been thinking on the same subject and I wanted to bring it up at the proper time, and I was going to suggest, or make a motion if necessary, that this committee, which is composed of five—a large number, generally speaking, to be handled on a committee—be composed of one member from each state that is represented here, and have this member act as chairman of the committee for his particular state. We have been three years at this; we have got started, but we are practically only started in New York and Pennsylvania, somewhat in New Jersey, and there are many of the states in which we have representatives where they have done nothing at all. I have corresponded with a great many different places, but the members have not been in a position where they thought it was their place to do it. By coming in closer contact with the committee I think we could get more active work. We are getting some enthusiasm among the members on this subject. Last year we talked the matter over considerably, but after the meeting they evidently forgot all about the subject, and although there was some correspondence, I could not get replies from a number of them. Some of those I wrote to were on the committee and some were not.

Mr. Wolfe: I think Mr. Carpenter makes a suggestion that will benefit the society and solve the problem. I hope that some one will make a motion that the committee on compulsory ventilation should consist of as many members as we have states represented in the society. The committee should have a chairman, and all the members within a state should be a sub-committee, represented in the society's committee by their chairman. I think in that way we would get the co-operation of all.

The President: I would like to say for the information of Mr. Wolfe that after appointing the committees last year I found that we should be materially assisted in New York state and in New Jersey by the help of some of our individual members, and I took upon myself to appoint one in New York City and one in New Jersey to work with the committee that was appointed, although their names do not appear on the committee. They materially assisted the committee in the work. I do not know but that the President has that power, and he could enlarge the committee in that way. The Board of Managers at one time undertook to do just what Mr. Wolfe is asking for now, and got severely reprimanded

for their pains. They appointed a committee of some 15 members, and they were told that they exceeded their powers in doing so. It was after the society had adjourned. At the next annual meeting, which was the first annual meeting I find that a resolution was adopted calling for a committee of five to be appointed on compulsory legislation. That has been followed up from that time to now. If it is the desire of the members to increase that committee it will be necessary to have a motion. If it is not the desire of the members to increase the committee there is no necessity for anything further.

Mr. Connolly: I make the motion that a committee on compulsory legislation of 15 be appointed, members of the society, with power to appoint sub-committees, and that the member from New York be chairman and the member from Pennsylvania vice-chairman. (Seconded.)

Mr. Meyer: I would like to ask if the business of this committee has been conducted largely by correspondence, or if when business is transacted it is necessary for the chairman to notify all the other members of the committee before any official action can be taken. If that is so it seems to me it might involve a degree of work for the chairman that he might not like to undertake if the committee is as large as proposed by Mr. Connolly.

Mr. Connolly: The idea of having a large committee is that sub-committees can be appointed in different states.

Mr. Meyer: How would it do for the president to have the power to name as many members of the committee as he sees fit, and the committee appoint sub-committees in the different states as they see fit.

Mr. Connolly: I will accept that.

Mr. Meyer: What I mean is, if you have fifteen members, can that committee do any work without notifying those fifteen members? It means a lot of letter-writing.

Mr. Wolfe: I understand that, but I should very much prefer personally that the committee should be composed of as many members as we have states represented in this society, and that each member of the committee from each state should be the chairman of a sub-committee consisting of all the members within his state. For instance, the chairman, or the member of the committee from New York City, should be the chairmain of the sub-committee consisting of all the members in New York State. Ohio the same.

Mr. Meyer: What I proposed gave the incoming President even more power than that, for it would authorize him to appoint just as many men on that committee as he saw fit.

Mr. Wolfe: That is a good deal of latitude.

The President: It has been moved and seconded that the Committee on Compulsory Legislation appointed by the President remain as it is—five; but that the President be empowered to appoint such additional sub-committees to work in conjunction with the Committee on Legislation as he may see fit to the best interests of the society. All in favor of that motion will say aye—contrary no.

The motion was carried.

Mr. B. H. Carpenter: If it is in order I would also like to make a motion that a committee be appointed by the chair in each city to investigate the heating and ventilating of at least five school buildings in each of the large cities of 100,000 inhabitants or over, we might say, and report at our next meeting. (Seconded.)

The President: I would ask if that committee is to work with the legislative committee, and be appointed by the President?

Mr. Carpenter: Yes—well, as is thought best.

Mr. Wolfe: We have not enough members to go round. There are a good many cities of 100,000 inhabitants.

The President: The motion that is just passed will allow the whole society to be a committee to carry out such points as will be necessary to facilitate legislation.

Mr. Wolfe: We must bear in mind one fact, that we have not any surplus to speak of in our treasury. It is not right to encumber the society with an indebtedness. No power should be given to the chairman or president to create a debt. I doubt if many of us want—I know I do not want to make a tour for two or three weeks at my own expense. So when we speak of committees for cities of 100,000 inhabitants or more I should like, if the gentleman will accept, to put in the words "in which we have a member." Then we could cover the ground.

Mr. Barron: I think Mr. Wolfe can get out of his difficulty very easily by remembering that the President has no power to spend a cent until he gets permission from the Board of Managers, and that the motion provides only for reports from such as will give them voluntarily. If a man is appointed on the committee he need not make any report, but it allows any gentleman who is appointed in any state on this committee by the President to submit a report. I think the motion covers just what we want to reach. We will get reports from enough shools to answer our purpose.

Mr. Wolfe: I rather differ with Mr. Barron in this matter. Members of a committee such as the Committee on Compulsory Legislation, the Committee on Uniform Contracts, etc., can submit

with propriety a report reporting progress, but when a committee is appointed to examine five schools they would have no reasonable excuse if during the year they did not visit the five schools, and it is going to put a man upon a committee where possibly the nearest city of 100,000 inhabitants might be at a considerable distance from his residence and he be put to considerable inconvenience and loss of time and money in making this examination. I hope that an amendment will be made to the extent of confining this committee to members who live in cities of 100,000 inhabitants or more.

Mr. B. H. Carpenter: In making that motion I had on my paper here the words "where we are represented." I should have read it but I did not—"to be appointed in each city where we are represented." Our representation generally comes from the larger cities, and it is in the larger cities that we want the investigation to be made. So I think the chair would not have a great deal of trouble in appointing men in these different cities who could make the investigations at very little or no expense to himself and none to the society.

The President: There is one point that I want to speak of before I put the motion. We have a committee on tests. It seems to me that the committee which it is now proposed to appoint would have to work through the Committee on Tests. I wanted to give the maker of the motion an opportunity to change it if he wanted to before we place it.

Mr. Barron: The proposed committee is not a committee on tests. I think that all Mr. Carpenter is aiming at, at least all I am aiming at, is this: A very reasonable excuse for not doing a thing is that you are not provided with money to do it. Prof. Kinealy can report on five schools in St. Louis without any trouble or expense. He could send us a report of one school in detail or a general report of all five. I can go into Jersey City and in two hours I can visit five schools, and I can report that the condition of the schools is so vile that further investigation is unnecessary. That is a definite statement not only for us but for various boards of education throughout the world if they choose to call for such information. It will not cost a cent. We know how all modern schools and those that are not modern are heated. What we want to know is the condition of the heating and ventilation of schools in various parts of the world.

Mr. Rockwood: It occurs to me that Mr. Carpenter and Mr. Barron may come a little closer together in what they respectively want if the word representative were put in before the word school bcause there is no advantage in knowing five schools unless we know

what those five schools represent in that city. For instance, in my own city we have many times five schools. I can show you five schools outrageous in character and other schools which are very fine. I do not know why five are suggested, but in any case it means five representative schools.

Mr. Wolfe: I think that any committee may be appointed with the fair understanding that it is very safe in their hands and that it can be left to their intelligence as to not running entirely in one line. I think that a committee of the city of Worcester would certainly choose possibly the average jobs. He would go along until he came to the best and strike a general average.

Mr. Connolly: I make an amendment to that. It is to be five schools in every city of over 100,000 inhabitants in every state. Why not make it five schools in one city of 100,000 inhabitants in each state.

The President: The question is where we have members or where we have representatives. If we have no representatives in a city of over 100,000 inhabitants it is not required to make tests. Am I right? You say to appoint a committee where we are represented —in all states where we are represented.

Mr. Carpenter: I think in each state where we are represented. I might change it around and put it in each city of over 100,000 inhabitants where we are represented, and then we might insert the words representative schools. I do not see any harm in that change and making the motion read that a committee be appointed in each city of 100,000 inhabitants or over where we are represented.

The President: You make it of five representative schools?

Mr. Wolfe: Leave that to the discretion of the committee.

The President: I think it is better the other way. They can take a poor and a good one then.

Mr. Wolfe: We must have comparisons. You cannot draw a conclusion without a comparison. That is the reason that two schools were reported yesterday as to the progress of the art of warming and ventilating school buildings, and the report of the committee yesterday was intended to show what had been done in the advancement of this science during twenty years. Now the committees in these cities, as recommended by Mr. Carpenter, of 100,000 inhabitants or more, of course will report on the different methods and the advancement. That is what we are for. We are a society, as I understand it, to keep pace with the times and the advanced methods of warming and ventilating buildings of the several classes. and to prove that we have advanced we first have to prove that they were worse when we started than they are now. Nothing will stand

still. It will grow better or grow worse, and the reports of these committees will show which way we have gone.

The President: Will Mr. Carpenter read the motion as it is now amended?

Mr. Carpenter: That a committee be appointed in each city of 100,000 inhabitants or over where we are represented to investigate the heating and ventilating of at least five school buildings and report at the next meeting.

The President: You have heard the motion. Are you ready for the question? All in favor will say aye—contrary no.

The motion was carried.

The meeting then adjourned until 2 P. M.

SESSION OF THURSDAY AFTERNOON.

The first business of this afternoon was the reading of the paper submitted by Mr. D. M. Nesbitt, member of the society, entitled "English practice in the warming and ventilation of technical and art schools." It was read by Mr. Wadsworth, and discussed by several members.

On motion of Mr. Wolfe a vote of thanks was tendered to Mr Nesbitt for his able and interesting paper.

Mr. Wolfe: I rise, possibly, to what might be called a question of privilege. It is on the subject of the report made by the committee of which I had the honor yesterday of being chairman. There have been criticisms, emanating probably from the article published in the "Herald" this morning, which, in the judgment of the committee, ought to be made right. If I properly understood the duties of that committee it was to show the advance or progress of the art in heating the ventilation of school buildings. Now, to arrive at a conclusion, of course it was necessary to have a comparison. Without wishing to criticize any one we took a building of a common type that was erected twenty years ago. You will find buildings like it in New York and you will find them in cities all over the country—a system of direct heating with very crowded rooms and no arrangement for ventilation whatever. We used that as a comparison of what was being done to-day, and as the report stated it has illustrated clearly and fully that the Board of Education of the City of New York, the school architects of the City of New York and their engineers understood and appreciated the necessity of good ventilation, and are keeping pace with the times so far as possible and so far as we know. I ask the permission of this society to submit our report intact to the New York "Herald" and ask them, in justice to ourselves, that they publish it intact, stating that we do no come

here to abuse the hospitality of the city of New York by finding the worst that they had; that we came here to find something simply for a comparison, to show what was done before heating and ventilation were much thought of, and what is being done by men who have studied the subject thoroughly. The "Herald" gave simply the poor side, without giving any idea that an advance is being made. I think it is an injustice to the city of New York, and I think it is an abuse of their hospitality to show only one side of the question, and I really understand that I have no right to submit any report to a newspaper without your consent. More than that, if the New York "Herald" decline to publish our report, or simply publish the good side of it as against the bad which they published this morning, that I may have the privilege of going possibly to some other newspaper who may set us right before the public.

After some discussion a resolution was passed authorizing the chairman of the committee, Mr. Wolfe, to visit the New York "Herald" and have it publish the entire report or to correct the version of the report as published.

The President: Next on the program is the paper by Mr. B. Harold Carpenter, entitled "Heating and Ventilating Church and Parish Buildings by Forced Draft."

The paper was read by Mr. Carpenter, and a discussion followed.

The President: The time has now arrived when the officers elected should take their positions and assume their duties. In retiring from this office I have to thank the officers and members for their assistance and support, which I would ask for the incoming President, whom I will now call upon to take the chair.

Mr. Connolly: I would like to put it in the form of a motion that you be thanked for your impartiality and fairness while in the chair.

The President: Out of order.

Mr. Wolfe: I would move that the vote be a rising one. Those in favor of the motion will signify by rising.

The motion was unanimously carried.

Mr. Wolfe then took the chair as president.

President Wolfe: Gentlemen, before assuming the duties of the office I wish to thank you most sincerely for the compliment, and to tell you that I cannot possibly express the gratitude which I feel for the kindness you show me. My only hope will be that I may be able to fulfill the duties of the office as well as my predecessor has fulfilled them. I think the aim and purpose of this society is to make heating and ventilation a profession that shall rank as high in the eyes of the people as any other profession in the country. The

question relating to school buildings is important. The man owning slaves in olden times was careful of them, so that the coming generation of slaves might be healthy and strong, and so commercially valuable. With the engineers of this country to-day lies the problem of impressing upon the minds of the public that good school ventilation is as much a necessity as school desks and school furniture. It has never been claimed that by entering a badly ventilated room a person immediately dies, but we all know that by inhaling a minute particle of poison it takes a certain amount of physical vitality to counteract it. Young children attending a school breathe continuously in schools without ventilation more or less poison every day. Every day their physical strength and vitality are called upon to a greater or less degree to counteract it. The result is that when they are taken with any disease incidental to childhood they have not the strength nor physical vitality to throw off its ill effects, and consequently the death rates are far beyond what they should be if the schools were supplied with pure air. As a matter of fact, the young children when they leave the schools in June are pale and generally run down. During the two months' vacation, taking no medicine, they exercise out of doors and that is all, and to a stranger a child leaving school in June and coming back in September again would hardly be recognized as one and the same scholar. I hope that I express the feelings of the gentlemen here and of the members of the society not present in saying that we will all try to work together to bring about the intention and the action of the people to this end. (Applause.)

The President: I have to announce the following committees for the ensuing year:

Compulsory Legislation: B. H. Carpenter, Wilkes-Barre, Pa.; N. P. Andrus, New York; George H. Mehring, Chicago, Ill.; T. B. Cryer, Newark, N. J.; Andrew Harvey, Detroit.

On Uniform Contract and Specifications: D. M. Quay, Chicago; H. D. Crane, Cincinnati; A. E. Kenrick, Brookline, Mass.; J. J. Blackmore, New York; A. C. Mott, Philadelphia.

On Standards: J. H. Kinealy, St. Louis; H. J. Barron, New York; William McMannis, New York.

On Tests: A. A. Carey, New York; B. F. Stangland, New York; Henry Adams, Washington.

On Nominations: William M. Mackay, New York, Chairman; R. C. Clarkson, Philadelphia; John A. Fish, Boston, Secretary; Charles M. Wilks, New York; Andrew Harvey, Detroit.

I will ask your indulgence before announcing the committee un-

der the motion this morning regarding the examination of the schools throughout the country until after I confer with the Board of Managers and Council. I would request the retiring Board of Managers to hold their final meeting at the close of this session. I request the new Board of Managers and Council to meet and organize at the end of the session.

The meeting was then adjourned.

PAPERS

OF THE

FOURTH ANNUAL MEETING,

New York, Jan. 25, 26, 27, 1899.

XXXIX

A NEW TYPE OF HOT BLAST RADIATOR.

BY GEORGE I. ROCKWOOD, WORCESTER, MASS.

(Member of the Society.)

Large radiators consisting of closely spaced banks of 1-inch wrought iron pipes, rising from and returning to cast iron supply bases, are being used in the United States more extensively to-day than ever before in connection with the so-called "hot blast" system of heating and ventilating buildings, and they may now be obtained from any one of a half-dozen important companies. Each manufacturer makes a specialty of one particular design of heater, for which design he does not fail to claim superiority over all others, or to declare it to be the only form of heater on the market which is really "made up in a manner to insure a perfect circulation in every foot of pipe." Notwithstanding this claim, a careful inspection of the drawings and engravings of these heaters, which each company publishes in sumptuous catalogues, will reveal two principal characteristics which are common to them all. The first of these is that however much one design may differ from another in respect to minor details, all consist of an aggregation of separate elements or sections composed of a hollow cast iron base into which is screwed a series of small wrought iron risers. Each such element is really a single radiator, for it has a single supply pipe and a single exhaust or drip pipe independently of its neighbors. To refer to an example in practice of this method of connecting the sections, suppose each section of a radiator has enough 1-inch pipes to give it an air-contact surface of 230 square feet, and that the radiator has in all eight or nine of these sections; then the supply piping would consist of a single 1½-inch supply pipe for each section, and these eight or nine 1½-inch pipes would all be connected to a single branch T, or header, which would be connected to a single large supply main, of perhaps five inches diameter. The drip connections are arranged in a similar manner. The other principal fact is that in no design of section on the market is provision made for automatic and positive expulsion of the air and the water of condensation, those two enemies to the complete progress of the steam to every portion of the section. In

fact, in any one of these heaters the entering steam is quite as likely to go at once to the drip pipes (thus getting in the rear of the air in the risers and holding the air back in the pipes for hours) as it is to go uniformly through every foot of pipe in the risers. In other words, the differences between the different designs of this common type, as modified by each manufacturer, relate only to the arrangement of the riser pipes, to the arrangement of the partitions in the base, and to the drip connections within the base.

There are, nevertheless, no vital objections to this type of hot blast radiator if the steam supply is under considerable pressure which is also maintained in the heater. To illustrate this, let us suppose the case of a heater supplied with steam under a pressure of 90 pounds per square inch by the gauge. At starting the pipes of the radiator will be full of air at practically 15 pounds pressure per square inch absolute. Now, even if none of this air leaves the heater by the drip pipes for a good while afterwards, the steam is nevertheless bound to find its way nearly all over the heater, simply because the air will be compressed into one-seventh of its former bulk, just as it would be in an air compressor in which the piston moved six-sevenths of its stroke before it could increase the pressure of atmospheric air to 90 pounds by the gauge. If, however, exhaust steam of little or no pressure above that of the atmosphere is the heating agent, then difficulty in heating the radiator uniformly may be expected with all the current designs of radiator. That this is not generally suspected to be the case I ascribe to two causes. In the first place there are the manufacturers' published claims to which reference has been made above. To say a word further in regard to these claims, I was told in conversation with a prominent manufacturer that few engineers were capable of estimating exactly the amount of heating surface needed in a given case, if exhaust steam were used without augmenting the pressure of the steam as it would come from the engine, because, he said, it is practically impossible to heat any known form of hot blast radiator uniformly, and the skill was in knowing by experience about how much of the heating surface would be "dead" and how much could be relied upon to be active under severe conditions of cold weather. The other reason for popular ignorance is that by far the greatest field of usefulness hitherto found for these heaters, and one in which they have been a pronounced success, is in connection with heating large rooms and halls used for public gathering places, such as public schools, churches, and theaters. In such places, as a general thing, no exhaust steam is available and boilers are relied upon as the main source of supply, and thus the pressure can be carried high enough

to provide the energetic action which these heaters need if the air is to be driven out of the risers.

The type of radiator which I am about to describe, and which is fully illustrated in the drawings accompanying this paper, is the outcome of my efforts to design a wind surface condenser on correct principles. My idea was to have this pipe condenser serve as a tempering coil in a large factory building and at the same time give the engine the benefit of as nearly perfect a vacuum as would be possible with such a condenser for the sake of economy of steam and to enable the engine to do as much work in the summer time as it did in the winter. I expected to use water instead of air to condense the steam in the summer. Before this tempering coil had been designed or built a large hot blast heater had been contracted for, set up, and put at work heating the building. This heater was like hundreds of others which the company had built before and which had "given satisfaction" to their owners. Therefore I had no thought of questioning the correctness of the principles upon which it had been designed. It was in two divisions, each consisting of nine sections, with 80 1-inch pipes in a section, each eight feet long. In the contract it was agreed that exhaust steam was to be the heating agent, and that, working in conjunction with the tempering coil, it should successfully heat the building under certain extreme conditions of cold weather. In one sense the terms of the contract have been fulfilled, as the building is nicely heated under those conditions with exhaust steam.

Previous to the time when the heater was at work it was my intention to make the tempering coil just like it. On reflection, however, and after observing carefully how the heater behaved, it became evident that, to be a success as a condenser, the tempering coil would have to be dripped differently. The air pump would short-circuit the steam through some one of the sections by causing it to pass up two or three risers and over to the drip system, leaving the other sections full of air and vapor. It was also plain that the steam must be so admitted to the condenser as to drive the air ahead of it in a positive manner. Making the steam connections to the different sections in "series" instead of in "multiple" would satisfy this condition, as the steam would then have to go through each and every section before it could appear at the vapor pipe leading to the air pump.

The most difficult problem, however, was to remove the water of condensation from each section without at the same time providing a path through which the steam could go with it to interfere with the steady action of the pump as soon as it should get

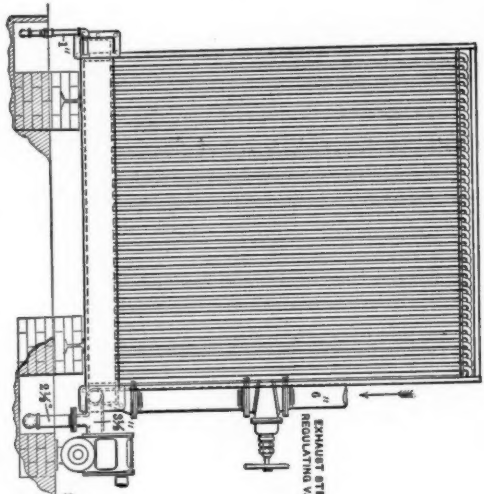

1"
2½"
3½"
6"
EXHAUST STEAM
REGULATING VALVE

FIG. 1

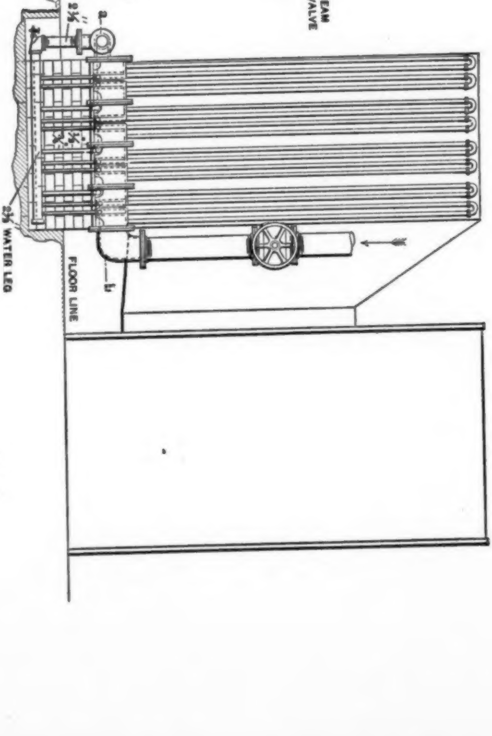
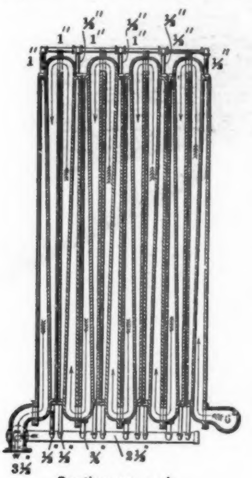

2½"
2½" WATER LEG
FLOOR LINE

FIG. 2

there. The water could not be trapped satisfactorily from a vacuum. Neither would it be best to connect it from base to base, as this might bring about both a short circuit and a water hammer. A separate pump might be used into which all the drips might connect, through siphons. This thought pointed to the solution of the difficulty; for by siphoning the several drips to the final section and making the drip pipe of this section quite large, to exhaust quickly the air driven ahead by the entering steam, a nearly perfect forced circulation is combined with a practical method of getting rid of the water of condensation. This plan was followed in the construction of the tempering coil, which contained about 1,400 square feet of heating surface. It has been in place now about two winters and has abundantly demonstrated its superiority to the much larger heater of standard make located by its side.



Section on a - b

FIG 3.

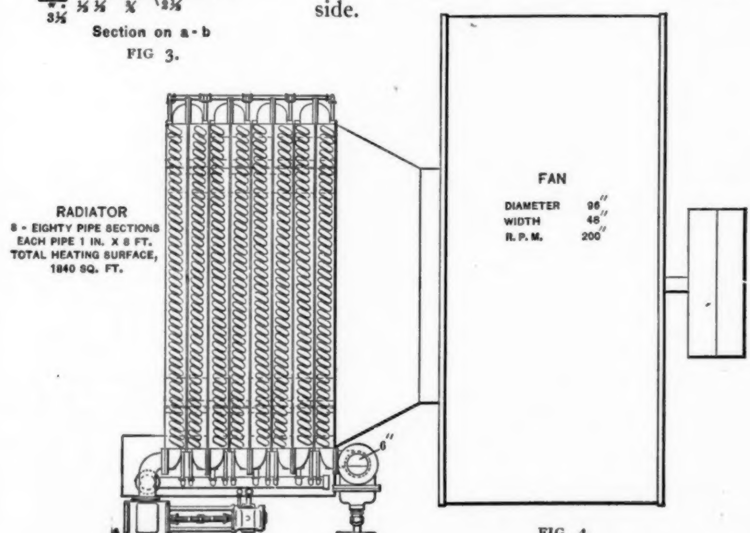


FIG. 4.

Description of Radiator.—In the engravings Fig. 1 is a front elevation of the radiator and air pump. Fig. 2 is a side elevation of the radiator and fan. A portion of the sheet iron housing of the

radiator is removed in this view to show the risers. Fig. 3 is a sectional plan view of the cast iron bases at a-b. The arrows show the course of the steam in passing from one section to another. The slanting partition divides the set of risers in a section from the returns in that section. Thus it is clear that the only path the steam can take, to get from one section to the next, is to ascend the risers and return through the return pipes; then it passes around the ends of two adjacent sections. The drips are clearly shown in this view, also in Fig. 4, which is a plan of heater, air pump, and fan. The sheet iron

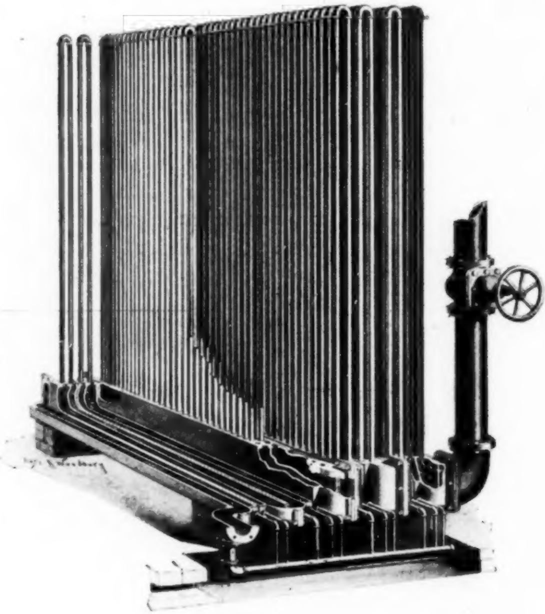


FIG. 5.

housing belonging on the top of the risers is, in this view, omitted to show them better. Figs. 5, 6 and 7 are perspective views which need no explanation.

Fig. 5 illustrates in perspective, and partly in section, a heater of the same size as the one shown in the preceding drawings, and the appearance of a single section-base is well shown in Fig. 6.

The same principles of steam supply and of water and air discharge which govern the construction of heater above described may be applied to almost any arrangement of pipes that a given situation may demand. A slight simplification of these principles is

exhibited in Fig. 7, and it has much to commend it. Its manner of working will, perhaps, be quite evident without the aid of working plans. In this design, as in the other one, the steam is first admitted

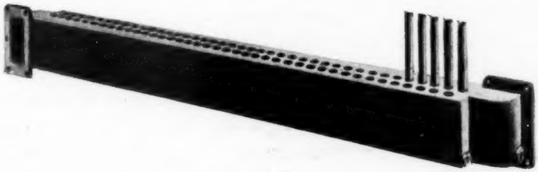


FIG. 6.

to an end section-base. The end bases are one-half the width of the intermediate bases, because they have but one line of risers each, instead of two lines. There is no longitudinal partition in any of these bases. The steam, once distributed in the first base, remains

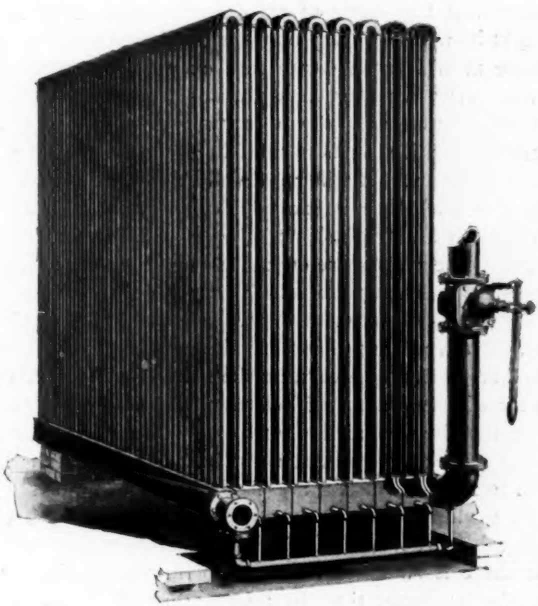


FIG. 7.

subdivided to the end of its course through the heater as each return pipe is directly opposite a riser of equal size. In this design the bases may be made about three-eighths of the weight of the bases in the other arrangement. Its defect is, that it must be constructed

in position, and cannot be shipped from the factory with the pipes in place, except in the smaller sizes.

So far as I know, this type of heater suffers from but one disadvantage, which is not theoretical, but is commercial in its nature. In order to provide enough "pipe capacity," if I may so describe it, or cross-sectional area, in the bases, they must be over twice the depth ordinarily allowed these castings. That is to say, the entire body of steam must pass through the first base; what is not condensed in that section must pass through the second, and so on. This means that cast iron for these bases will cost twice as much as in an ordinary radiator. On the other hand, however, greater depth of casting in the present type would do it no harm, for the tendency is to make these bases too small to provide room for the steam, water, and air to pass each other comfortably. The difficulty has been partially surmounted by slanting the partition dividing each section in the manner shown in Fig. 3. If theoretical considerations alone controlled the shape of each section base, then a different depth might be used for every one, the maximum depth being given to the base at which the steam first enters. The cost of pattern making, however, which such a gradation of depths would entail, taken in connection with the advantage to a thorough diffusion which greater depth than is absolutely necessary would give, prohibits such a design. It will be obvious from an inspection of the drawings that each base is exactly like every other in all respects except that half are "rights" and the other half are "lefts." One pattern and one core box are enough to mould either a "right" or a "left" by simply drilling the 1-inch pipe holes on one side of the casting for one kind and on the other side for the other kind.

One of the advantages of constructing a radiator in the way here shown is that one large valve takes the place of many smaller ones as a regulator of the amount of heat admitted to the entire radiator. This valve may be regulated automatically to maintain the temperature of the room at a constant point, thereby permitting the speed of the fan to remain constant and thus give at all times the required degree of ventilation. This is a point which deserves emphasis. There are school rooms in which the air is foul, notwithstanding the fact that there is sufficient fan capacity in the ventilating system, the cause being simply that the temperature of the room is varied by varying the speed of the fan instead of the amount of heat admitted to the heater. Another advantage is that no matter how much or how little steam is admitted to the radiator, the heating effect extends entirely across the radiator. One section cannot be heated at all until the section behind it is entirely heated.

The specific points of superiority of this heater over the ordinary, or multiple supply, heater are four in number:

1. The impossibility of air binding.
2. The simplicity of the means for regulating the supply of steam.
3. The uniformity with which the pipes in any section are heated.
4. The perfection of the method of dripping the sections, which occurs without noise or waste of steam.

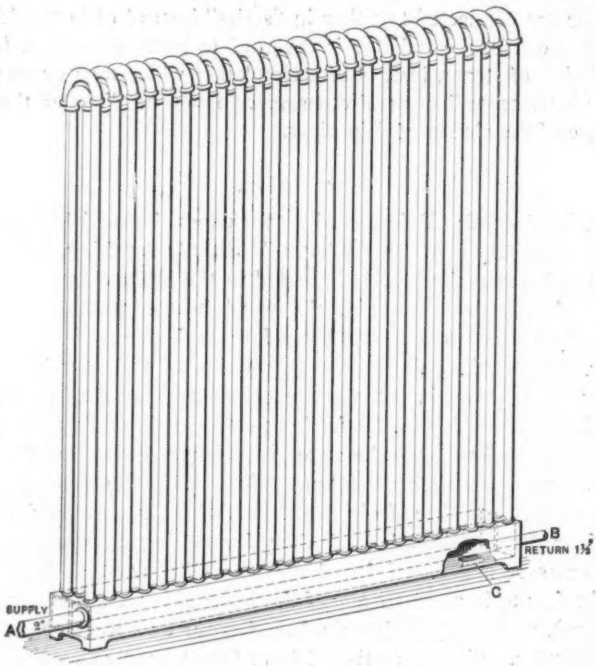
In conclusion I will restate that the new type of radiator shown is chiefly advantageous to use with steam of low or atmospheric pressure and that this is chiefly due to the fact that the different sections are connected together in "series" instead of in "multiple." In other words, the radiator is designed to really produce a forced circulation of steam, instead of a circulation which may or may not take place, according as circumstances favor or disfavor the free passage of the air out of drip pipes.

DISCUSSION.

Mr. Rockwood: Before reading the paper, I would like to state why I called my heater a "radiator." Strictly speaking, it is not a radiator, because the heat is imparted to the air by contact. I use the word radiator rather than the word heater, because "heater" generally means not a steam, but a furnace, heater.

Mr. Stewart A. Jellett: The description of this new heater interests me very much. Some statements made in the paper, however, I take exception to. Referring to the existing forms of heaters, the gentleman has made the statement that the heaters on the market at the present time are intended for high pressure steam only. I have used a number of different forms of fan heaters, and I have but four heaters in all (and they for drying purposes), using high pressure steam. I found the same difficulty that Mr. Rockwood refers to in a great many of the types of heaters (namely, back pressure), and finally designed a base for our own work to get over the difficulty. Since that time I have found, practically, the same heater made by one of the blower manufacturing companies. Whether it is modeled after what we had already done or not, I cannot say. It is very similar in a great many points. When the blower is driven by an engine, I always use the exhaust steam in the heater. There is no trouble in filling all parts of the heater with exhaust steam. It is supplemented, however, through a reducing valve, with steam at from ½ pound to 3 pounds pressure. In some cases I take one section of the heater and run the exhaust steam into it only, and drip it, independently of the other four or five sections.

This is done in order to trap the other five, not wishing to trap the section in which the exhaust steam is being used. It depends altogether on the size of the engine used in connection with the fan as to the number of sections to which the exhaust steam is connected, the object being to condense it all. In small systems I find that one base section, which would be four rows of pipe in depth by six or seven feet in height, will condense all the steam coming from the engine. In other cases I have had to use two sections. I connect the exhaust steam to the sections where the cold air enters at the



back of the heater, if I am drawing, or directly in front of the fan if a forcing fan is used. I do this with the object of condensing the steam as fast as I can in those sections and making use of it. The great objection I find to the established types of heaters is, that the pipes are spaced too close to allow sufficient air to pass. More systems of hot blast heating fail because there is not area enough between and around the pipes to pass the air which the fan is capable of delivering than from any other single reason. I have examined systems that have ample heating surface, but were failures, because suffi-

cient area had not been allowed for the passage of the required volume of air. The form of base I use for fan or hot blast heating is divided lengthwise, which is the usual way now, I think, but the pipes are spaced further apart than in the usual commercial form. The inside of the base is graded toward the return; the return outlets being large, the air valve is placed on the return end. I can probably describe it better by sketching it than I can any other way. The steam (referring to a sketch) is entering at this point A. Take this as the feed end, on a section of heater that has perhaps 200 square feet of surface using exhaust steam. This steam supply connection will be 2-inch diameter. The discharge of the condensation (B) be on a line slightly below the inlet, the inside of the casting grading from the inlet and to the opposite end. The return connection will be about 1½ inches diameter. When we come to the upper part of this heater—the pipes—I use a close return bend for the middle rows and a wide pattern return bend for the outer rows. The bases are all tapped right hand. The return bends are all left hand. There are only two lengths of pipe used in this heater. The inner pipes will be, if I recollect right, about an inch and three-quarters shorter than the outer length. The pipes used are all cut to a standard length, so that you do not have that difficulty of making up a number of pipes and of differing lengths, with consequent danger of leakage, due to expansion at the elbows of joints. Consider the circulation; the steam cannot get out from the feed section except it rise through the pipes and pass out the return side. The pipes are all uniform in height and spacing. There is no obstruction, but the smooth pipe between the base and the projection on the return bend at the top. The area is perfectly uniform. The spacing between the pipes is three-eighths of an inch greater than in any type of heater that I know of. The condensation that collects on the feed side of the base passes out through a small opening in the dividing web, where the steam cannot follow it, unless there is a great pressure, as shown at C. The air valve is placed on the return end of the base. It is found that the circulation of steam is practically instantaneous. Take a heater of six sections in depth, twenty-four pipes, each section being twenty-four pipes wide, and some six feet in height, and turn the steam on the sections, and as fast as you can pass your hand over them the steam has followed. A point of advantage in heaters having independent sections is the fact that one section can be instantly cut out of service, should a leak be found, and the balance of heater continuing in use. Now, if your heater is one unit, your heat is shut off from the building. With

a heater such as I have described, we do not stop the heating system for a moment. My experience has been, that in heating with low pressure steam at one pound pressure, or with exhaust steam, that you rarely get the temperature of the air higher than 167 degrees Fahrenheit, with the average velocity used in a building (which we will assume to be 1,800 or 2,000 feet from the mouth of the fan) using a heater some twenty pipes in depth, with a good circulation in and around, you can get the air just leaving the fan at from 165 to 167 degrees, assuming it enters at zero. If you extend the heater to forty pipes in depth, you will only gain between four and five degrees. I have never been able to get the air over 172 degrees with low pressure steam. The practical limitation I have figured on in designing a heater for warming a building has been twenty-four pipes in depth, with sufficient sectional area between and around the pipes to allow for a full delivery of the air that the fan supplies plus a reasonable allowance for its expansion due to increase in temperature, and a reasonable amount for friction. The point particularly to be observed is that of free and sufficient area for the fan capacity, and then to bring the air in contact with a certain number of rows of pipes or heating surface, which my experience has shown to be twenty to twenty-four pipes in depth. I heard an agent of one of the large blower manufacturing concerns make the rather broad statement, a short time ago, that the measure of the condensing capacity of a fan heater properly designed was the limit of capacity of its return pipe to carry off condensation, and that he could continue to condense as long as he could carry the water away by increasing the velocities of air over the surface. I will not go so far as that, but I will say that there is a greater amount of work to be gotten from a fan heater, when well proportioned, than most heating engineers imagine; that such a heater can do a great deal more work than it is usually intended to do, if it is proportioned so that there shall be a free circulation to meet the incoming volume of air. Within the last five years I have placed in my own work in the neighborhood of 100 of this type of heater, some of them heating as much as 70,000 cubic feet of air a minute, all giving good results.

Mr. Barron: I would like to know Mr. Jellett's idea as to the relative efficiency of horizontal surface and vertical surface in heaters.

Mr. Jellett: This (referring to sketch) is very much superior in this way, that the travel of water in condensation is so very great in the box coil. In box coil work, I have in mind a case where we had a section of a room for drying glue, seven feet high, eight feet wide. (Making a sketch.) I was using exhaust steam. The heat lasted until

about here. Here the pipes were cold. Down here the condensation was frozen in the pipes. I had to cut that heater here and here, and heat it at three points. With the vertical pipes we have a heater seven feet high; the maximum travel is fourteen feet. The maximum travel here, plus the friction, is very much greater. Take an ordinary box coil six feet long, and the travel of the steam would be something over 100 feet, plus the friction of a great number of turns. I found the temperature of the air there might be 167, and down here it might be from 110 to 130. The condensation is going on all the time, and by the time you get down here your pipe is practically filled with water, if your air is cold. In this form, your condensation here on this side, with no pressure back of it, is dropping here simply the height of the seven feet of pipe, whatever it may be.

Mr. Barron: Mr. Rockwood provides a drip in his. Don't you think there would be some danger of his coil freezing up?

Mr. Jellett: I think not. I believe each base is dripped independently.

Mr. Barron: Don't you think even with those drips, there would be some danger, if the fan was running very fast?

Mr. Jellett: Not necessarily. I think you could drip each one of those sections so as to clear it.

Mr. Fowler: For several years the fan system at the normal school at Lockhaven, Pa., had given a great deal of trouble, on account of the bursting of manifolds during the winter, and several times they had to close the school for three or four days in order to repair those manifolds. It was one of the well-known systems of the fan radiator, and they finally decided to have a change made there, and I was called in consultation with the engineer, and we finally devised a plan almost similar to Mr. Jellett's, with some little variation, perhaps a little more simple. The base piece was omitted, and the result was at least 50 per cent. more efficiency for this past winter. Those patterns can be had by anybody that wants to use them, and my statement can be verified by the evidence of the Board of Directors of that school.

Mr. Jellett: I do not know that I can enlarge on what I have said, except possibly to show some of the present forms. The form that most of us have used, and a great many have had trouble with, I imagine, is this plan (making a sketch) with a single pipe, or sheet iron diaphragm at the center. What first led me to go into this question of heater bases was a case where I was using heaters of this type, and I found by making tests on the delivery side that in the center the temperature was practically the same as the incoming tem-

perature to the fan. As the thermometer was moved from the center toward either side the temperature increased, until at the outer sides I was getting my best results. I found it to vary over the whole surface; there was no uniformity. I found also with a heater divided in this way, with the long bases and the form of diaphragm that was formerly used, it was possible to air-bind all the inner pipes of the section. In a number of cases where I experimented with it, with a very slight manipulation of the valve, such as a man would do when he was in a hurry, I have found a blast of air equivalent to about one-third of the entire volume coming through at exactly the same temperature as it entered the fan. The results beyond it were

not, of course, very satisfactory. But in the form I first described this cannot happen, as all pipes are vertical, and are carried down into the base. There is a positive division in the base, and this division is the full length of the section. The air valve being on the opposite side from the entering of the steam, insures a complete circulation. I use the old form of automatic air valve that is used on indirect radiators, because they give greater expansion. I have in mind one particular shop where the exhausts from two engines, one high speed electric light engine and one Corliss engine, are connected to these heaters. There are two separate shops and two separate fan systems. The exhausts are carried through one main into both of these heaters. In the summer we let the city water cir-

culate through the heaters for cooling the shops, drawing the air over the surface of the pipes to lower the temperature of the air. We find that it affects the temperature in the shop about six degrees. When the temperature outside is 95, six degrees is a considerable help, particularly when a large volume of fresh air accompanies it. There is no patent on this and anybody can use it.

Mr. Rockwood: The type of coil that Mr. Jellett describes is not unlike one that is widely used in hot blast work at present.

Each section of Mr. Jellett's heater has a double set of risers and a double set of returns, whereas in the type to which I refer each section has a single set of risers and returns. That is the principal point of difference between them. The two types are alike, in that air and water must pass out through the same outlet. But this outlet must be sealed by being connected to a trap, in order to prevent waste of steam through any single section, and hence the current of air, steam and water through the outlet can hardly be positive or sure in direction.

Air will move out of a pipe at considerable velocity with the merest fraction of a pound of pressure applied uniformly at one end only of the pipe—as is done in my circulating type of hot blast heater, where each section empties its steam and air (but not its drip) into the next section in the series. But if the air from a large section has no place to go except it escape through a tiny crack in an air valve, a relatively considerable increase in pressure of the steam supply will be required to force it, little by little, out through the trap.

Mr. Jellett's radiator has the common defect of all multiple supply radiators in this particular. If you throttle down on the supply system of the radiator to a degree that prevents it getting as much steam as would heat every pipe if uniformly supplied to each section, it begins to cool down all along on one side first (making a sketch). If A B is the entire width of the radiator and you are admitting steam at A, and if more steam is condensed than is supplied —in other words, not enough steam is supplied to complete the heating of the radiator—you commence to cool down across all the sections at B. Now, the air may go across on that side at a higher velocity than on the hot side of the radiator. At any rate, you cannot be sure it will not do so. If the fact were that when you throttled off steam, you did so on but one section at a time, then on another, and so on, you would still keep the remaining sections hot all over, just as I accomplish it in the new type of heater; but to do this you must shut off both supply and drip pipes, all the way across,

and you have to pay close attention too, because the next hour you may want those valves all open again. The result is that engineers do not attend to these valves, if provided, and the regulation does not in fact take place. Mr. Barron asked about the tendency of the heater to freeze. In discussing this heater with Prof. Woodbridge, of Boston, he suggested the liability of the heater to freeze unless steam entered it on the cold air side. I had not thought of the matter, really, one way or the other, because my heater has been at work for two years, and water has not been frozen in it at any time. I condense perhaps a pound and ahalf of water to the square foot of heating surface per hour. I can imagine cases in which it might freeze, and as there is no reason why I should not admit steam at the cold air side, I think that might prove the best arrangement.

Mr. Jellett: I would like to ask Mr. Rockwood if he has experimented to see what he could gain on the difference between inside and outside temperatures of the air.

Mr. Rockwood: I have not. I meant to study that effect under various conditions of temperature and humidity of the outside air in the case of the heater which forms the subject of my paper. But I know this single fact that on one occasion when the outside temperature was 14 degrees above zero, the temperature of the air after it travels across the 14 sections was 120°; 14 above zero to 120 above zero was the increase.

Mr. Barron: I would like to ask Mr. Rockwood to give us a little information about air condensers.

Mr. Rockwood: An air condenser is a hot blast radiator used to produce a vacuum in a steam engine cylinder. I estimate the necessary pipe area on the assumption that a square foot of cooling surface will condense a pound and a half of steam per hour, which is about what it will do when the air is 20 degrees outside.

Mr. Paul: May I ask one question? He says that he does not use a trap, and that he does not use a pump. I would like to know what he uses on the boiler.

Mr. Rockwood: I have a pump which returns the water from the heater to an elevated tank. Now, this is an air pump which was intended to create a vacuum in the radiator when used as an air condenser. So leaky is that condenser that I have been unable to hold the vacuum, and now I make no attempt to secure it. I allow a drip pipe 3" diameter to be opened to the sewer, and I open that when we start up if it were not desired to run the pump. I have made rough experiments on the pressure needed to produce circulation of steam through the condenser, and I find that one-quarter

of a pound of pressure was sufficient to cause the complete circulation. The temperature of the outside air was 14 degrees above zero. The pump could be used to a great advantage in an extra large coil to quickly warm up the heater. It aids the circulation undoubtedly, and I think a pump for that purpose is a good thing. There is one trick, however, in working a vacuum pump in connection with a set of coils of this character which is worth knowing. A prominent company that has offices in town, and is well known, uses a vacuum pump on the returns from a heating system, and causes cold water to be fed into the supply to the pump, to chill any *vapor* which may find its way back into the pump. It is condensed, and thus the cold jet of water prevents the pump from kicking and slamming. On the pump which is put into my plant I have three cylinders. The first cylinder is a vacuum cylinder, the second is a steam cylinder, and the third is a dash-pot, in effect. This dash-pot was built into the pump to furnish circulating water. It now pumps the water round and round, and when any steam comes over through the vacuum cylinder, which it very frequently does, that cylinder entirely prevents thrashing and slamming of the pump pistons.

Mr. Barron: Before the discussion closes there is one statement made by Mr. Jellett which I do not think ought to go without some comment, that is, as to his experience in horizontal heaters—that they generally freeze up. The impression from what he said would be that horizontal heaters generally freeze up. There are a number of firms in this country who for many years have made nothing else, and from their experience freezing is the exception. A horizontal heater is certainly more efficient in work. Of course, I do not contend for a moment that the vertical form is not the correct form, but there is no reason for us to conclude that a horizontal form will not yet be developed that will be superior, since the fact is that a horizontal pipe hot with air impinging on it will heat a great deal more surface than a vertical pipe. Of course, the whole tendency of design is the other way, and rightly so. But from Mr. Jellett's remarks the impression that you receive would be that American engineers have come to the conclusion that no one but a fool would put in a horizontal coil.

Mr. H. C. Meyer: I would like to ask Mr. Jellett a question, if I may, and that is if he has ever made any experiments to determine the average condensation per square foot in such a hot blast heater as he has described; I mean a heater in which the air is raised from zero to 120 degrees, passing through the coil at a maximum velocity of 2,000 feet per minute, the coils 24 in number, and also what ef-

fect the steam pressure in the coils has upon the final temperature of the air.

Mr. Jellett: That is a question I cannot answer, for this reason: No two heaters that we put up are alike. We are contracting engineers, and when we finish the work and make the test for delivery of air we do not generally have the time to make a series of tests such as Mr. Meyer describes.

Mr. Meyer: I mean such a heater as you described.

Mr. Jellett: One set of tests of that kind would really be of no practical value for the next piece of work. If I had time to make such tests for information I would very gladly do it, but I am one of the men who have not hours enough in the day, as a rule. As a matter of fact, to make a set of tests that amounts to anything means to do it over a period of time. Two or three times we have taken a certain amount of data, and had to abandon the tests by the use of the building before we could carry it out our own way. The tests were not completed, and we never have made any record, or given out any information, because they were not complete. While we are on this question of fan heaters, it occurs to me that so far we have not touched on the cast iron indirect radiator forms which are being used in place of the ordinary type. The gold pin radiator, others built something like a coil with three loops, are used in banks, the air being carried through two or more banks. We have had very good results from these, but they are generally used where the air is at exceedingly low velocity. The forms that are used for school houses, institution work and churches, where very low velocities are required, are without number. It all depends on the velocity of air that we expect to deliver into the ducts, and the space in which the heater must be set—the form of heater that is applied to the work.

Mr. B. H. Carpenter: I would like to ask Mr. Jellett if he uses a cast iron radiator in the same proportion of heating surface as he would the pipe coil; that is, one foot of inch pipe coil to the square foot of radiating surface.

Mr. Jellett: No, I do not. The extended surface I do not consider at all as an effective surface. It is only effective in the sense that it divides the air currents and directs them against the surface which has direct steam on it.

For the information of the members I would say at the present time I am putting in a fan system of heating in a private house. I am using broad, flat coils, disc fans driven by electric motor, returning the water of condensation from the coils directly to the boiler. It is

the case of a very fine private house, where they want good ventilation. They do not want an engineer or engines on the premises, so we designed to use gravity boilers, indirect radiation for most of the house, supplemented by the fan with tempering coils, and in the chilly weather of fall and spring we use only the tempering coil with the fan, and add the indirects at the base of the flues when the cold weather sets in. We get the necessary power from the current which lights the house. In this way, when the owners give a ball or reception the system will give them the amount of fresh air they require. We have a 54-inch disc fan discharging into a system of ducts delivering air to all parts of the house. It is the first application of the fan system on an extended scale to a private house that I have been connected with. We are warming the building now for the use of the mechanics who are at work there, and we find no difficulty in returning by gravity with this apparatus.

Mr. B. H. Carpenter: Do you have the heating coils all at one place, or distributed at the base of the flue with a by-pass around?

Mr. Jellett: We have no by-pass at the fan heater. We have indirect radiators at the base of the flues in the usual manner.

Mr. Carpenter: Then to control the amount of heat in the room, allowing for a certain amount of ventilation, you would have to control the valves on the radiators in the basement; they are not automatic?

Mr. Jellett: They are not at the present time. They probably will be controlled by thermostats.

Mr. Carpenter: In regard to indirect cast iron radiators, have you ever experimented and found how many stacks of indirect placed one above another would give you the same results, as you say, from the 24 pipes?

Mr. Jellett: Yes. Where I could bank my heater together pretty well I have used two banks of radiators with the three-section loop radiator. This is equivalent to six sections in heignt, three on the lower tier and three again on the upper tier, and generally set off at an angle, so that the air clears the first or lower bank before entering the second, and is then led from the top of the second tier at the end of the heating chamber. In every case where I have used these indirect radiator heaters I have used disc fans or blowers at very low velocity.

Mr. Barron: I would like to say a word about Mr. Jellett's remark about extended surface. Everyone does not agree with him that extended surface is valueless except for directing currents of air. I think a foot of extended surface at a given temperature is equal to

any other surface. Whether it is extended or non-extended I cannot see and never could see any difference. It is a mere matter of expediency in proportion. Of course, you can put on so much surface as to destroy the efficiency; but I mean within reasonable limits that his surface is almost as good as what is called prime surface.

Mr. Kent: If it is necessary to have the record straight, I think it might be well to say that the proper statement is exactly one-half way between Mr. Barron's statement and Mr. Jellett's, Mr. Jellett saying it is no use, and Mr. Barron that it is equal to any other surface. I think it is right to say it is about half way between—it is about half as good as any other surface.

Mr. Barron: I am willing to compromise on that every time.

XL.

SOME EXPERIMENTS IN STEAM CIRCULATION.

BY JOHN GORMLY, PHILADELPHIA, PA.

(Member of the Society.)

Having occasion recently to locate a steam boiler of the pattern usually designated a "saddle boiler," with a fire 12 by 16 inches, and a maximum rated capacity of 150 square feet of radiation, tapped 2½ inches on the top for a steam pipe, I attached to it 120 square feet of steam radiation. The mains, not being covered, would run the radiation up to 150 square feet. Of this amount 25 feet were on the third floor, 45 feet on the second floor, and 50 feet on the first floor. The boiler was located in the basement in such manner that in no case was there more than 12 feet of a horizontal run. The pipes were graded with a fall of one inch in ten feet. I connected all the radiators on the single pipe system, the condensation being returned through the feed pipe of each radiator. I placed on each radiator an automatic air valve with a hard rubber pencil, the expansion of which closed the valve when heated. All radiators containing above 25 square feet of surface had 1¼-inch connection; all below that size had 1-inch pipe. So far I followed customary practice, but I could not refrain from experimenting on so small a plant, because the cost would be little and a demonstration would be as effective as one on a more expensive apparatus. I therefore graded the pipes so that the rise was from the boiler to the radiators, placing no drip or relief pipes on the job. The water of condensation necessarily ran in a contrary direction to that in which the steam traveled. There was no other connection between the bottom and the top of the boiler than a 1¼-inch pipe, to the side of which the water column and gauge glass were attached. The boiler was connected to an excellent flue. On firing up the water remained in the water glass until one-half pound was registered on the gauge. At that pressure the water disappeared down the water glass with a steady motion and so swiftly that in ten seconds it was out of sight. I then opened the fire door. The water returned as swiftly as it had gone. I repeated this experiment several times, the disappearance and return of the water occurring each time. Had I been experi-

menting to discover a pump to throw water to the upper floors with one-half pound pressure this apparatus would have been a success. I then tried to determine the effect of placing ¾-inch drip pipes at the foot of all the vertical risers, of which there were three. These drip pipes were carried separately to the base of the boiler and there attached to it. On again firing I was somewhat surprised to discover that I had made no change in the working of the apparatus, unless it was to accelerate the disappearance of the water. I then assumed that the automatic air valves could be blamed for part of the effect, the loose hard rubber stems of the valves slipping over the passage from the valves into the radiators and acting as a check to the admission of air when a partial vacuum was in the radiators. I then replaced the automatic valves with others having no rubber pencil, but operating with a metallic bar, which, by expansion and contraction, opened and closed the valves. These were positive in action and could not be closed unless the radiator was filled with steam. On firing up again I had the same result as at first, which was a surprise.

I now looked to the boiler for the cause of this peculiar action. I noticed that when the water line of the glass was out of sight there was always a steady stream of water, very small, but yet very perceptible, running spirally down the glass on the inside. I decided to tap the two main steam branches close to the boiler and directly above it, in such a manner that any water running along the bottom of the mains would be intercepted. It was also intended that this pipe should act as an equalizing pipe. It was made large and the base of it tapped into the bottom of the boiler. When again fired up it was found that a steady water line was maintained. The plant has now been running steadily for two months. It gives entire satisfaction.

I have concluded that in this instance the form of the boiler was the cause of the peculiar action of the water. The boiler had probably no more than an inch of water surrounding the fire box. There was no local circulation possible in the boiler as it came from the makers. I believe all boilers should have a good circulation of the water contained in them, and that a steam boiler should contain much more water within itself than a water boiler. I wish to call special attention to the fact that in this experiment all the radiators, even to the third floor, were apparently filled to the line of the automatic valves with water. As the third floor radiator was about 30 feet above the boiler, and as we had but one-half pound of steam on the plant, I should like to have the views of our members as to the cause of water being forced to that height.

As the automatic valves were open and could not be closed while they were cold, it was not a vacuum that held the water in the radiators, but what did hold the water there? Personally, I incline to the view that the pipes and radiators were filled with globules or bubbles of water and steam alternating with each other in much the same manner that water is pumped by the Pohle pump, except that in the Pohle system air is used instead of steam. I believe these globules or bubbles would be materially assisted in their formation by the oil left in all pipes by the fitters. On mentioning the peculiar action of this job to a friend he assured me that with the same make of boiler a vertical line of single pipe to three floors had acted in much the same manner with him, but in his case the lower radiator was hot and the radiators on the second and third floors remained cold and were partially filled with water. He remedied the trouble by tapping the boiler both at the water line and at the base, then connecting the two taps with a 2-inch pipe. This settled the trouble. His water line was a disappearing one before he made the connection on the boiler which I have described.

DISCUSSION.

Mr. Gormly: Perhaps I should have prefaced this paper with the remark that it was prepared with a view to bringing out discussion, and to having our members express their views concerning certain failures that I suppose some of them have had. I know that I have seen a number of heating plants that were not a success, that I did not put up myself. I would like to hear from some of the other members; that is the principal reason why I have prepared this paper. Mr. Gormly exhibited an apparatus illustrating some of the statements in his paper.

Mr. J. A. Connolly: I would like to ask Mr. Gormly a few questions.

First: He states that the boiler was connected to an excellent flue. I would like to know the size of the flue.

Second: I would like to know the height of cellar and the height of water line on the saddle back boiler.

Third: Where were the air valves on the radiator; that is, what part of the radiator.

Mr. Gormly: I would reply by saying that the flue was about 8" x 8" and the height of the cellar was, I think, about 7 feet. The height of the water line was 41½ inches. The air valves were located, I think, half way up the radiator, the radiators being about 30 inches high.

President Mackay: One question more, Mr. Gormly: Is that the height of the water line from the base on which the boiler stands or the bottom of the boiler?

Mr. Gormly: That is the height of water line that is given by the makers, and I suppose it is the height from the floor.

President Mackay: There is a 12-inch base below that?

Mr. Gormly: I think not—41½" above the floor line is the water line.

Mr. J. J. Blackmore: Is the radiator on the third floor just 30 feet above the water line?

Mr. Gormly: That is approximate; I did not measure it exactly

Mr. Blackmore: What is the height of the floor?

Mr. Gormly: About ten feet, I think.

Mr. Blackmore: Did you notice as much water on the top floor as on the second floor?

Mr. Gormly: The only way we noticed the water was by having it thrown out of the automatic valve, and it came out on the top floor as much as on any floor.

Mr. G. I. Rockwood: For how long a time did it keep coming out?

Mr. Gormly: We did not let it come out very long. As soon as we saw it we stopped it. People were living in the house. We allowed it to run 20 minutes at a time, several times.

Mr. Rockwood: How did you know that the water was in the radiator?

Mr. Gormly: We saw the water come out of the radiator.

Mr. Rockwood: Reason and experience would lead you to suppose that water was not in the radiators if there was nothing to hold it up in the radiators.

Mr. Gormly: That is right; but something held it up in the radiator.

Mr. Rockwood: Then, if there was no pressure to hold the water up in the radiator, it could not be there, so far as reasoning goes, and we do not know that it was there. It could not be assumed to be there.

Mr. Gormly: I do not think that necessarily follows at all. We can assume the water which we saw coming out of the radiator was in the radiator.

Mr. Connolly: Mr. Gormly states that there was no circulation possible in the boiler as it came from the makers. He says the size of the flue was 64 square inches, and the size of the grate surface was 192 square inches. That is a proportion of one to three; there is not a boiler manufactured in this way that would not prime, and

that would not force water up; and when he said he had a most excellent flue, he certainly had a flue that was altogether too large for the grate surface.

Mr. H. J. Barron: This is a case where the steam fitter is sure that it is the fault of the man who makes the boiler, and where the man who makes the boiler is sure that it is the fault of the steam fitter. I think the boiler man is right. My assistant asked me a few weeks ago if we should put a connection from the top of the boiler to the line of risers. He said, "It will save so and so." I said, "Certainly, anything to save." And we did it. This was a six-story building. When the work was put up, this riser filled up with water just as Mr. Gormly's does. The rest of the plant worked all right. The foreman asked what we should do. I said, "Drip the risers." We dripped them, and that ended the trouble. If Mr. Gormly did the same thing it would end his trouble. To-day, in all boilers, commercial conditions make it necessary to reduce the steam space of the boilers. Of course, I cannot take in all the phases of this question, but the object of heating boiler design is to make a boiler as cheap as possible.

Mr. Connolly: I would like to set you right about drips. Mr. Gormly states in his paper that he put on three-quarter inch drips. You put on one that cured it. Mr. Gormly put on three and he said that the water was accelerated.

Mr. Barron: I do not pretend to solve Mr. Gormly's problem; I can only assume from my own conditions. But I know that putting a drip on settled that matter, and I know you can settle almost the worst case of heating boiler priming by dripping risers. We are working closer to the water line to-day than ever before. In the morning when the steam gets up, the mains of course being cold, there is a great deal of condensation and the water backs up and seals. Then after a while steam comes along and the water is pushed up the riser and the riser is sealed all day. We usually fix that by double covering the pipes and having properly sized drips. I think in every case where these difficulties occur it is the fault of the steam pipes. I think a decent steam fitter can make the worst boiler that was ever designed give good circulation. Circulation is a question for the steam fitter. A man can hardly design a boiler so poor that a steam fitter cannot get decent circulation out of it, so far as that goes.

Mr. Gormly: I would like to answer Mr. Connolly. He makes the assertion that there is not a boiler built that would not prime under those conditions.

Mr. Connolly: I said that there was not a boiler proportioned in that way that would not prime.

Mr. Gormly: We still retain the same proportions. We cannot prime now. The boiler is working now satisfactorily.

Mr. Connolly: I said that if that proportion of flue surface was carried out in the same way, and grate surface, that the boiler was without local circulation and would prime under those circumstances. Mr. Gormly has cured it. Mr. Gormly can take the same boiler again, probably in another house, and fit it up as he did this, and the boiler will probably work. He says, "I believe all boilers should have a good circulation of the water contained in them, and that a steam boiler should contain much more water within itself than a water boiler." I do not believe that. I think Mr. Kent, perhaps, can give us some information on that.

Mr. William Kent: I do not know how far we can cut down the steam space in the boiler. I know in one case where it was cut down to nothing. I refer to the boilers used for the hot water distributing system in Boston. The boilers were filled with water, and also the mains, and the water burst into steam when it reached the customer's premises. I think the failure of that system was not due to the boilers but was simply a commercial matter—it was too expensive. So really steam space does not seem to be necessary for a boiler at all, if you allow some place for the water to jump into steam before it reaches the steam pipes.

Mr. Barron: I would like to add to my remarks that this circulating pipe that Mr. Gormly puts in cured priming; that it takes care of the priming just as it should. Some years ago Mr. Barrus wrote a leter to the "American Machinist" about how he cured a vertical boiler, which had been crowded by too many tubes. He called attention to the error that steam fitters were making, and he showed how he cured it by filling up a lot of the tubes. I wrote a letter to the "American Machinist" saying that if he had put in a drip he would have cured it in a less expensive way. That was, of course, poor engineering, and the editor threw it in the waste paper basket. There is so much mystery—we have to assume a whole lot of conditions. When we get on a certain job we know what exists there, and the ordinary steam fitter soons finds the remedy. But in dealing with Mr. Gormly's paper we have to assume a lot of conditions. It is like the problem that an English king gave to the philosophers: Take a pail full of water and put a fish in it, and the water does not run over. Why is that? The water does run over all the same.

Mr. B. H. Carpenter: I think there are cases where the boilers are at fault. We had a case some few years ago where, after connecting, one side of the house worked all right and the other side of the

house did not. It puzzled us for some time until we put an equalizing pipe from the poor side of the house back to the base of the boiler and tapped the boiler. It was a cast iron sectional boiler, upright sections, and it worked all right, proving to us that there was no circulation on that side of the boiler. The return had been brought around on the other side, and the supposition was that there was a circulation through the rear section of the boiler, but the poor side did not work at all. It threw water out of the radiators all the time.

Mr. A. E. Kenrick: I have had a case that I have been working on for two years up to last October, and equalizing pipes and everything else were tried without effect. Fnally we took the boiler out and put another one in, and it is all right. It is an entirely different boiler, and the boiler man, after he had exhausted everything else, said, "The whole trouble was in the pipe," and the other man said, "Put my boiler in and don't change a thing." We did so, and it worked all right.

Mr. Barron: I can readily understand that. The boiler Mr. Kenrick put in probably had much larger steam space than the one he displaced, and that would account for it possibly.

Mr. Kenrick: I think not.

Mr. Blackmore: There is a point that comes up in Mr. Gormly's paper—one point he directly raises and another he has brought up since. The first is how the water could be on the second floor. I contend that the pressure in the boiler did not drive it there at all other than this. If he had a half pound pressure there was virtually $15\frac{1}{2}$ pounds absolute pressure in the boiler. That absolute pressure was sufficient to raise the water up in the pipe 16 feet. I asked Mr. Gormly the question whether the second floor had more water than the third. Mr. Gormly does not seem to be quite clear on that point. I feel quite certain myself that there was only a small quantity of water in the radiator, and that it was kept there because the riser was blocked by the water that was in it. After the water had risen in the riser for 16 feet it would stay there. Every time you lowered the pressure that returned to the boiler. So that every time you fired up a certain amount of wet steam went into the radiator upstairs. I think if he had taken a pail there and drawn that water out, he would have found it would soon have stopped in that radiator. So, I believe it would have continued in the radiator upstairs so long as the pressure in the boiler was half a pound or even at atmosphere. I do not think that it occured through any action that Mr. Gormly explains in this little arrangement here; because here is the water distinctly above the air. If we put an air bubble in the bottom of a tank of water it will come instantly to the top, and it may carry

some moisture with it, but the conditions are not as shown in this experiment. I mention that because it might be misunderstood that the water up there was due first to the pressure in the boiler and to the amount that went up in the form of wet steam, and steam will carry a great deal of water, Mr. Gormly says here in the form of globules. It makes very little difference what form it takes—it does it. Now, the other was in the size of the boiler. Mr. Gormly says there is a space all round. It is a well known fact that if you narrow the water space in a boiler below the point at which steam can freely escape through it, it will carry it up if the water space is wide enough so that all the steam that is generated from the surface down there can escape to the surface. Then no more is needed. But if it is contracted down half an inch, steam would be generated so rapidly that it would throw all the water out of the stack. Whether that was the case with the boiler Mr. Gormly referred to or not, I don't know. But if it was, the steam would be generated rapidly and the top would boil over, and it would get up into the risers and the absolute pressure in the boiler would hold it there. Is the pipe that he put in there proportioned to relieve that? He says he provides a circulation —allows the water to ascend freely as soon as it escapes at the surface; he makes a return circulation for it, and that everything goes round and round—the water travels round and round, whereas before the space was contracted—it could not return.

Mr. Connolly: He states that he put the drips on and that it did not cure it, so that theory does not work out.

Mr. Blackmore: He spoke of dripping the riser.

Mr. Connolly: You are talking about the pressure on the second floor. Now, he has taken off just two feet, and it did not cure it.

Mr. Blackmore: The drips on the riser would make no difference under the conditions I am speaking of.

Mr. Connolly: You are figuring on the basis of atmospheric pressure, and you state that it is hermetically sealed in the riser. Now, if he drips it at the bottom of the riser——

Mr. Blackmore: It would not make any difference. The water would stay there just the same.

Mr. Connolly: Then drips are not valuable.

Mr. Blackmore: Under those conditions, no.

Mr. H. M. Swetland: I would like to ask the last gentleman how a pressure of half a pound could possibly sustain a column of water 16 feet, unless he had an absolute vacuum on the other side of it. It seems to me this must be wrong. Unless there is an absolute vacuum beyond the column, I do not see how half a pound pressure could sustain this column at this height.

Mr. Blackmore: In a steam apparatus of that kind—we can assume that there is an apparatus—we have a closed substance. At one end of that apparatus we generate a pressure of 15 pounds, and that pressure can not get to the other apparatus. There must be a vacuum. It is unequally balanced and it will go up and down.

Mr. Gormly: I would like to ask how he could have a vacuum with several automatic valves open which could not close, and they were operated well up on the radiators. They were possibly in the center of the radiators and pretty well up in the job. One was on the third floor, several on the second, and some on the first, and those automatic valves were open and could not be closed. How can you maintain a vacuum with automatic valves open?

Mr. Rockwood: Can you give us the relation between the volume of water in the heater and the volume in the riser before the first radiator was reached?

Mr. Gormly: I do not know except that we ran two and a half inch pipes. I suppose the water in the heater would have filled the pipes and partly filled all the radiators, but I do not think there was sufficient water in there to entirely fill the radiators and pipes.

Mr. Connolly: I would assume that the radiators on the first floor and the pipe would just about balance the water in the boiler.

Mr. Barron: Of course we have to make so many assumptions that it makes the problem rather academic. I can say from my own experience that with a double pipe system where you run the mains close to the water line, or with a single pipe system dripped under the same conditions, you are apt to have this occur from time to time; but if you use a continuous main single pipe system, I do not think you will have any trouble. I think that is a solution of the difficulty of most jobs, and I would not give so much time to this subject if I did not have lots of trouble of this kind myself. We all depend on the working men, on the draftsmen very often, and this occurs, I guess, in the best establishments—I know it occurs in some of the worst, my own among the number. It is a serious problem. Now, the men who use a continuous main single pipe system largely have the least trouble of this kind. I never have that trouble with a continuous main single pipe system. I have run that system as close to water line as I would dare to do with a drip single pipe or double pipe system.

Mr. Gormly: In respect to the single pipe system that Mr. Barron advocates, I would say that we had a case in which we used the single pipe circuit on a steam job; we also had six feet in the clear between the water line of our boiler and our first radiator, and we found that upon firing up the water did leave our boiler. Then after

experimenting for a number of hours we found that it was necessary for us to reduce or to take half of our circuit that we had above the water line, and run it below the water line. When we did that we had no further trouble with the job, which led me to believe that we practically added that much more water to the water of our boiler. Otherwise we had evaporated the water that was in our boiler to fill the circuit and left our boiler dry; but when we made part of our circuit a return main we had no further difficulty. The water line then remained steady. That is one instance in which the continuous circuit single pipe system was a dismal failure until we made part of it a water line.

Mr. Connolly: I would like to have President Mackay's experience.

President Mackay: I do not know that I can say much more than has been stated on the subject. I think that the greatest part of the trouble is due to the lack of internal circulation, and frequently from lack of sufficient volume of water. I found that trouble with lack of a proper body of water in proportion to the surface, or the lack of proper circulation, and that the force of the stream has raised the water up to the upper floors. It acts very much like the cylinder of a pump.

Mr. Connolly: I am going to differ with the President about the body of water. A boiler was placed on the second floor of a commercial house down in Gold street. The job was two pipe. The drips and returns were all sealed above the water line, and there was a space of twenty-six inches from the first radiator to the water line of the boiler, and we put in circulating pipes and drips around the boiler, and we could not cure it. We took the boiler out and put in another boiler one size larger, though the original boiler was not overrated, and it went along all right. We took this same boiler and put it in a one pipe job at Gramercy Park, with overhead drips, not a continuous circuit, and the boiler is working to perfection to-day.

President Mackay: On as much surface as it had in the original job?

Mr. Connolly: Yes, sir.

Mr. Gifford: I believe very thoroughly in the endless main system, and with this in view I erected a heating system very much as the gentleman has described. I had the same trouble that he described. My smallest job was inch and a quarter pipe, on 25 feet of radiation on the second floor. I got more water in that radiator than I did in any other. I had another job where I had similar trouble with the same kind of a boiler. I asked the manufacturer to

come and criticize my pattern. He came and looked it over. He said to me "Take the boiler out and send it back to the factory and we will send you another one." We connected the other boiler that he sent us on the same system without a particle of alteration in the piping, and it worked perfectly.

Mr. B. H. Carpenter: This discussion recalls to me a circumstance which occurred a few years ago, which is a little similar, and I would like to ask if anybody can enlighten me in regard to the why and wherefore of it. We had a horizontal tubular boiler which was already in a school building on a low pressure system with direct and indirect radiators. We put in a fan and heater and a trap to return the water in the system. After testing the boiler we found it capable of carrying a little pressure, and we carried about 30 or 40 pounds pressure. It happened about ten o'clock every morning that the water disappeared. There was no place for it to disappear, as it could not get through the check valves on the trap unless it went through the feed pipe. There was probably about 2,000 feet of heating surface in the heater, and there was only a three inch pipe on top of the boiler. The flange was not large enough and we could not change it very well, and we thought we would try it, and the water disappeared every morning from the boiler right out of the gauge glass. I was at a loss to account for it, and I inquired of an old boilermaker whether he could give a solution. The boiler had a dome. The pipe was taken from the top of the dome. He said "Tap the rear of the boiler with about a three-quarter inch pipe and connect that with the steam pipe," which we did, and it overcame all the trouble. As I said, the three inch pipe was taken from the top of the shell in the rear on to about 2,000 feet of heating surface. I never could account for it, but it solved the problem.

A Member: I would like to ask Mr. Gormly a question. If he had put a positive air valve on the radiator on the top floor, would he have drawn three parts of the water in the system out? Mr. Blackmore says 16 feet is the height of the water.

Mr. Gormly: I really don't know what we might get if we had a positive valve on top, because I do not know how much water was in there, but I suppose if we had a positive valve there we would have got water out of it. I know we did get it out of all the valves that we had that were automatic, and I suppose we would have got it out of the top of the radiator. There is no reason why we should not have got it, I think.

Mr. Barron: I think Mr. Gormly's statement about the water being much higher than what is due to the pressure is quite believable. I think many of us have had that experience. I think

that water must go up somewhat on the hydraulic ram principle. In other words, I do not know anyhing about it, but I have my theory. I believe that the water does go much higher than any pressure that is due to the boiler or due to the boiler and vacuum, and if it is forced up there, that it does not come back even with the air valve opening and the so-called vacuum being destroyed. You must remember that the opening of the air valve is merely a pin hole. It takes a long while for the pressure of the atmosphere to balance. Mr. Gormly says he had the water up there. I think he knows what he is talking about. It is pretty hard to account for that and reason it out as a physicist would reason it out.

Mr. Andrew Harvey: It seems to me that we are talking without getting at any point at all, because everybody is figuring from his own theory, and we have no real data. Mr. Gormly has not really given us the actual data of what it did. He has not given us exactly the amount of steam space he had in his boilers, and the whole thing is a supposition. It is on the same principle that an engineer in the government once asked an engineer that came to get his papers, what he would do if his pump was all right, the valves were all tight, and he could not get the pump to work. He said he would look overboard and see if there was any water in the river. So I think the facts are similar here. If the boiler had not sufficient steam space or sufficient water space or if the pipes were run in such a way that they would not free themselves of water, I think it remains for the steam fitter to see that here is more steam capacity or water capacity for his pipes; so I think the whole thing resolves itself down to a man's practical knowledge in putting up the plant.

Mr. H. C. Meyer, Jr.: I want to ask if the phenomenon cannot be duplicated by having what chemists call a small test tube, simply a glass tube closed at one end. If you hold it in a flame of gas you can drive every particle of water from it. If you take the same tube and bend it round so as to make circulation, the bubbling action will not take place. It seems to me these boilers or most of them have been designed in which a return connection at the bottom is contemplated, so that the water can get back at the fire surface as fast as it is driven off in bubbles of steam. It does seem a little bit unfair perhaps, to the manufacturer, to take his boiler and connect it by a single pipe to the system so that the water cannot get back, and it is put in use in a way which was never intended.

Mr Gormly: Mr. Meyer is right in that respect, and I will tell you how I know it. We took the same make of boiler and put it on a water job where everything was filled with water, and where it had excellent opportunity to do its best. Our return pipe came in on

one side of the boiler only. The result was that when we fired up the thing worked very nicely apparently, but after it was in a little while we had a cracked plate, and we replaced the boiler with a new one, but we took the precaution to make a circulation to the opposite side of the boiler from which the return came in, so that we would have returns to both sides of the boiler. We fired that as hard as we knew how, and we never had any trouble with it. We know that the boiler really requires and must have a return to both sides of it in order to work safely. In other words, a water boiler on a water system had forced the water out of itself on one side until it became so hot that it cracked, and when we put a return circulation to that side, we had no further trouble.

Mr. Connolly: Mr. Gormly says that there was no connection to the return after he had finished his first job, except an inch and a quarter pipe. I presume that is taken from the front end of the top of the boiler and carried down either on the right or the left side. Now, take a nipple and a bull-headed tee and carry down the inch and a quarter pipe on the right and left sides, place the gauge glass on one side and the cocks on the other; I think possibly he could get the job to work.

President Mackay: I know of a particular construction of boiler that worked very satisfactorily, but the manufacturers were losing a good many of their castings on account of the thinness of the iron. They thickened up their castings, and reducing the body of water in the same construction made it act just as Mr. Gormly speaks of now—lifting the water, where the previous construction, made from the same pattern, not thickened up, but having the proper amount of water that should be in that type of steam boiler, did not lift the water under exactly the same conditions of piping.

XLI.

A TEST OF THE HEATING AND VENTILATING PLANT, NEW YORK STATE VETERINARY COLLEGE, CORNELL UNIVERSITY, ITHACA, N. Y.

BY PROF. R. C. CARPENTER, ITHACA, N. Y.,

(Member of the Society.)

The test described in this paper was made under my direction, and in accordance with instructions, by John Hulett and Frederick Noe, graduates in mechanical engineering, class of 1897, for a graduating thesis. Some portions of the paper, especially that relating to the reports of the test, are copied from the thesis referred to, and otherwise I find myself under obligation to the gentlemen named.

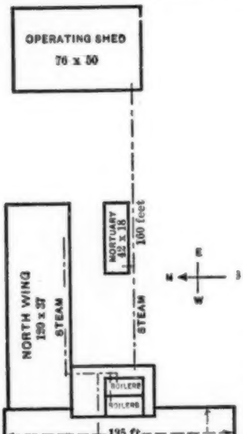


FIG. 1.—GENERAL PLAN OF BUILDINGS, N. Y. S. VETERINARY COLLEGE.

Description of Buildings.—The New York State Veterinary College comprises six buildings and is located on the Cornell University campus, on the east side of East avenue, the buildings being arranged as shown in the general plan. Fig. 1. The erection of the buildings was begun in 1895 and completed in the spring of 1896, Professor C. Francis Osborne, formerly of the College of Architecture, being the architect. The buildings are arranged as follows: A main building, three stories in height, in which are located the offices, lecture rooms, museum, laboratories, and, in the basement, the heating and ventilating plant; the north wing to this building, one story in height, containing the anatomical theater, laboratory, preparation room, locker, and lavatory; a mortuary building located in the rectangle formed by the main building and north wing at two sides; an operating shed east of the mortuary; and the stables and

the isolated wards for contagious diseases, which are located to the east and south, and which are not shown on the plan and not heated from the main plant. The operating shed is built of wood; all other buildings are of buff brick and of slow burning construction, viz., all the inner walls are finished in brick and painted, the timbers are all extra heavy and exposed to view, the flooring and sheeting on the roof is laid over plank, the ceilings are of narrow pine, and in general no enclosed spaces are left. The roofs are all covered with tin and the trimmings in the interior of the main building are of oak. The building is lighted, except in the north wing and operating shed, through side windows; in the former the principal light comes through skylights in the roof. Except on the three stories of the main building, all floors are of concrete. A vault in the rear of this building and on a level with the basement contains the boilers, crematory, and cold storage.

The exposure of walls and windows to the weather is about as follows:

MAIN BUILDING.	BRICK WALL.	GLASS.
On the north about	3366 Sq. Ft.	644 Sq. Ft.
" " south "	3366 " "	644 " "
" " east "	9339 " "	1546 " "
" " west "	9504 " "	1572 " "
Surfaces covered by tin roof	6074 " "	
NORTH WING.		
Total exposed wall surface	6069 " "	
" roof "	4875 " "	
Sky-light surface	552 " "	
Window "	170 " "	

DESCRIPTION OF PLANT.—The heating and ventilating plant in the veterinary college was installed during the spring of 1896 from the designs and under the direction of Henry B. Prather, member of the American Society of Heating and Ventilating Engineers. It is located in the basement of the main building, the plan of which (Fig. 6) shows the general arrangement of the plant, which is composed of two separate systems: First, a direct radiating or heating system, with radiators in each room of the main building and wing and in the operating shed and mortuary. All the radiators are of cast iron, double piped, and so arranged that, at the option of the engineer, the condensed steam is returned either directly to the boilers or to a receiver, from which it is pumped into them. The direct system is intended to heat the main building and the wing during the night when the fans are not in use, or air is not needed for ventilation, also in cold weather to assist the fans during a short time in the morning, but is not used when ventilation is required or during school hours. It is the only system provided for

heating the mortuary, the museum and operating shed, and, as being of little interest, is not considered further in this paper. It is merely an auxiliary to the main system, except for the room specified above. The north side of the main building and wing are slightly protected by a hill; all other sides are about equally exposed to the winds. The appearance of main building, as seen in elevation, with north wing in perspective, is shown in Fig. 2. The plans of the various floors, with arrangement of vent and heat ducts, are shown in Figs. 3 to 5. Each room has heat and vent flues independent of any other, and these are generally proportioned so as to give velocities less than 600 feet per minute for supply and

FIG. 2.—GENERAL PERSPECTIVE VIEW OF BUILDINGS.

750 for discharge. The principal dimensions of the various rooms and certain particulars in relation to the heating apparatus are given in Table I.

Second, the main heating and ventilating system, which is arranged to supply by forced circulation a constant volume of air, the air being heated a sufficient amount to maintain the rooms at a uniform temperature, consists of two fans connected to engines by belts, the necessary heating coils, air pipes, etc. This system is used throughout the entire school time for supplying heat and air for all the lecture rooms and principal rooms of the main building, except the museum, and is the only system considered in detail in this pa-

per. In the operation of the plant the fans are run only during the school hours, from 8 A. M. to 5 P. M., or a sufficient time before 8 A. M. to have the building thoroughly warmed. During the night the building is practically unoccupied; no ventilation is required, and it is heated by this system of direct radiation referred to.

The forced blast system is subdivided into two parts and either part can be run separately as desired. On the north is situated the larger fan, which delivers air to the north wing and lecture room; on the south is located the smaller fan, which delivers air to the offices

TABLE I.—DIMENSIONS OF PRINCIPAL ROOMS.

Room.	Cubic Contents.	No. of Persons.	Air Flue Dimensions	Air Register.	Vent. Register.	Direct Radiating Sq. Ft.
First Floor.	Cu. Ft.		Inches.	Inches.	Inches.	
No. 1*	4,920	10	8x7½ H 6x7½ T	10x15	8x15	40
No. 2*	3,600	10	"	10x15	8x15	40
No. 3*	4,920	10	"	10x15	8x15	40
No. 4	3,600	12	"	10x15	8x15	40
Museum	39,366	10	0			210
South Hall	7,200		0			110
North Hall	7,200		0			100
No. 5	20,800	135	3(8x24) H 3(6x24) T	4(21x29)	2(24x2) 2(24x16)	80
Second Floor.						
No. 8	5,904	12	8x7⅛ H 6x7⅛ T	12x20	10x20	40
No. 9*	5,904	10	"	14x20	10x20	40
No. 11*	5,904	10	"	12x20	10x20	40
No. 12*	5,904	10	"	14x20	10x20	40
Museum and Temp. Lecture Room	34,992	10	0		0	240
South Hall	3,600		0		0	0
North Hall	3,600		0		0	0
Third Floor.						
No. 13*	5,904	10	8x7½ 6x7½	14x20	10x20	40
No. 14*	5,904	10	"	14x20	12x20	40
No. 15	20,893	40	2 (8x8) (8x6)	2(20x24)	2(18x21)	100
No. 16	13,488	40	2 (8x8) (8x8)	2(18x24)	18x20 18x21	100
No. 17*	5,904	10	8x7½ 6x7½	12x24	12x20	40
No. 18	5,904	10	"	14x20	12x20	40
North Wing, First Floor.			3(16x24)	3(16x24)	3(16x20)	400
No. 6	39,600	40	3(16x20)	3(16x20)	3(20x24)	
Closets and Lockers No. 7.		10		2(10x16)	10x16	80

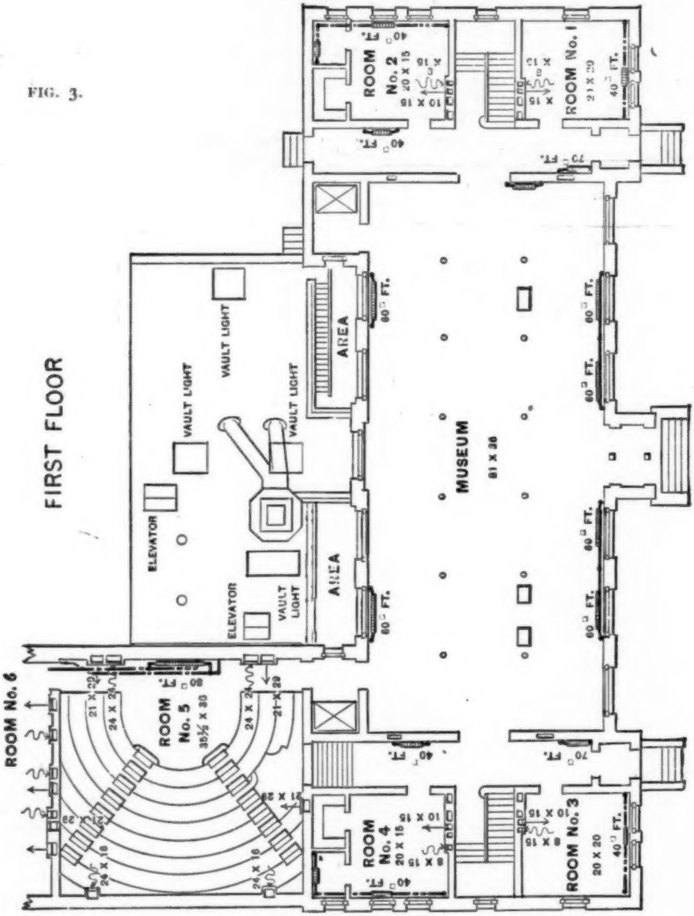
*Offices and Studies assumed as containing 10 people.

in the south end of the main building. This subdivision was made so that when the south offices were not in use the ventilating fan supplying them with air need not be operated, a condition which was believed would often exist, but which in practice has been found to seldom occur.

The cold air enters the building through two windows; from these it is carried to the cold air rooms, shown on basement plan, and before entering which it is passed through fine wire screens to remove any large particles of dust which might be drawn in. Air

from the museum, which is usually unoccupied, can also, when desired, by the opening of certain registers, be drawn into each cold air room and mixed with air from the outside. From the cold air rooms it is drawn into the fans through a coil of steam piping known

FIG. 3.



as the "tempering coil," the office of which is to warm or temper all the air entering the building to between 65 and 70 degrees; in case the entering air is already near this temperature, the damper is so adjusted that the entering air passes underneath the tempering coil and through the by-pass.

The air pipe from each fan and through which the air is forced is separated into two pipes, one above the other. The upper and larger one contains a chamber in which is placed a number of steam coils similar to the tempering coil. This is called the heater, its duty being to raise the temperature of the air passing through the warm air pipe from 65 or 70 degrees to 100 to 150 degrees.

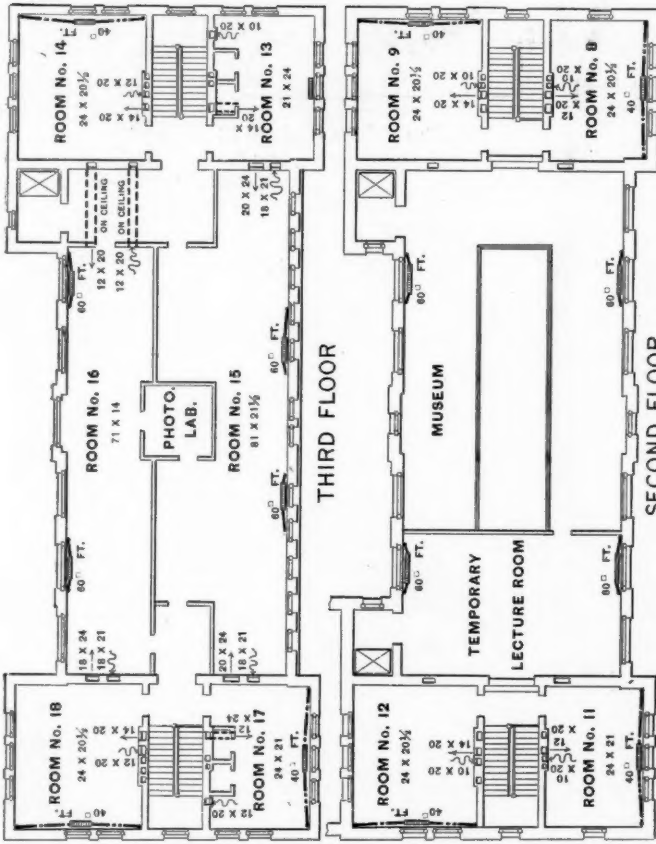


FIG. 4.

The arrangement of the heating surface for each fan is more minutely described later; for the large fan 954 square feet of heating surface is placed in the tempering coil and 3,816 feet in the heater coil; for the small fan 396 square feet is arranged in the tempering coil, 1,584 square feet in the heater coil.

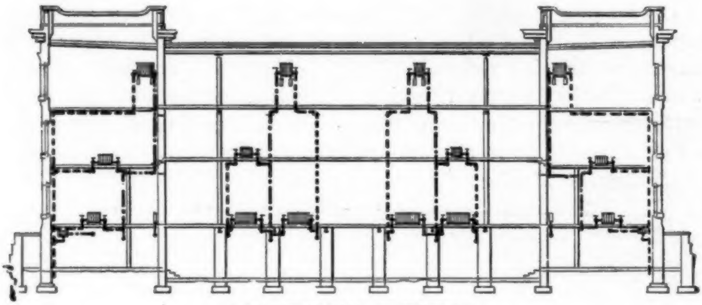


FIG. 5.

LONGITUDINAL ELEVATION
Looking at Front Wall

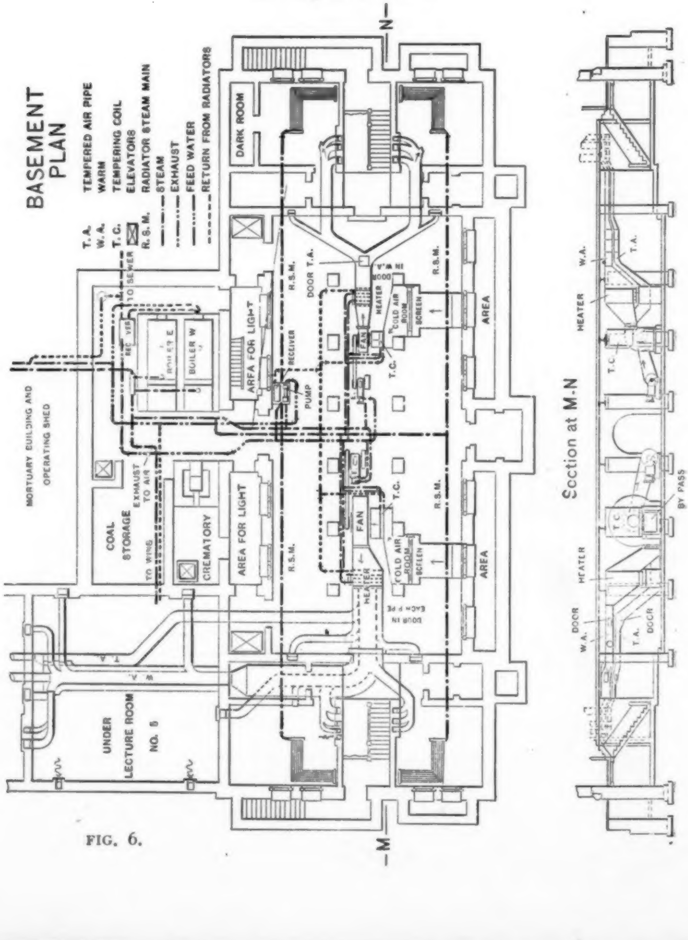


FIG. 6.

The general arrangement of the system is shown in Fig. 7, from which it is seen that air is taken in from the outside at A, is passed through or under the tempering coil T, depending on the position of the damper D. This damper may be regulated as desired, either by a thermostat or by hand. The blower is placed at F and serves to draw in the air from the outside, also to force it over the heating

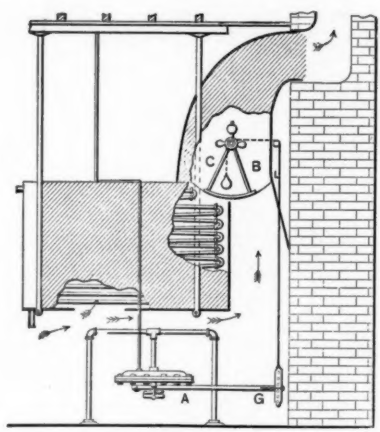


FIG. 7^2.

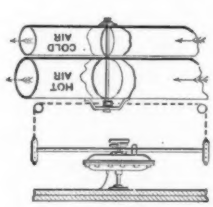


FIG. 7^3.

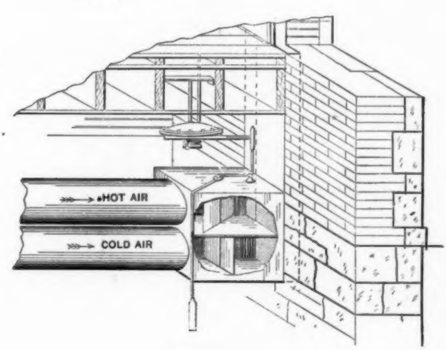
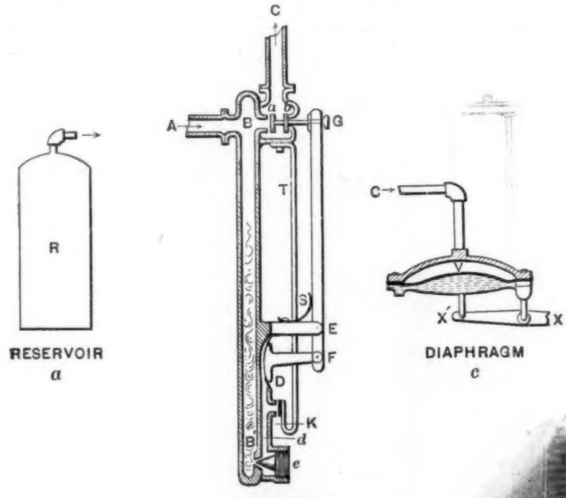


FIG. 7^1.

surface at A and into the warm air chamber, also through an opening in front of the heater and into the cool air chamber. From the warm air chamber and also from the cool air chamber pipes are led to a vertical flue (which we will term the mixing flue), connecting with the rooms to be heated. These pipes are controlled by a single damper, which is so adjusted that either the warm air pipe or

the cold air pipe can be opened as desired, but the total supply of air cannot be changed by any motion of the damper. These dampers are made in a great variety of forms and have been used for many



RESERVOIR
a

THERMOSTAT
b

DIAPHRAGM
c

FIG. 9.

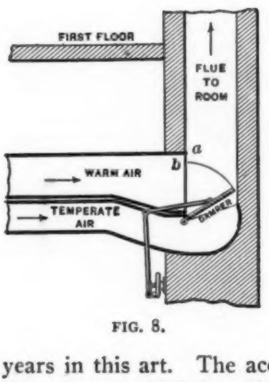


FIG. 8.

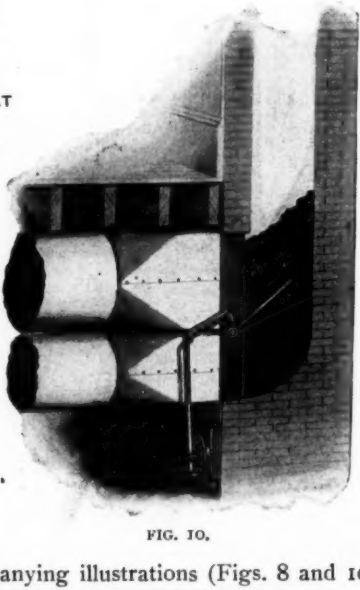


FIG. 10.

years in this art. The accompanying illustrations (Figs. 8 and 10) show forms which have been employed for such functions.

The damper being adjusted, a certain amount of warm air and cool air is admitted to the common flue as necessary to maintain the proper temperature in the room to be warmed. A thermostat, whose

motion is controlled by the change of temperature in the room to be heated, can be attached by proper mechanism, and in such a manner as to regulate the position of the damper corresponding to a demand for heat in the room. Such an arrangement is shown in Fig. 10 for regulating the position of the damper by means of a diaphragm or damper regulator controlled by the thermostat.

TEMPERATURE REGULATION.—In each room supplied with air from the fans is placed a thermostat, which is so constructed that with a change of temperature in the room the movable part of the thermostat will either supply or discharge, as required, a charge of compressed air into a chamber or vessel with a movable wall, as, for instance, a diaphragm, connected so as to regulate the supply of heated air. The temperature regulator is of the pneumatic type, as described above, and its principles of operation are illustrated by Fig. 9. It consists, first, of an air compressor, not shown in the diagram, which is operated by water power so as to maintain a constant pressure, say 20 pounds, on the system. This may be stored in a reservoir R or simply in the pipes in the building. The principle of operation of the thermostat is illustrated by the diagram, although the details of construction of the actual instrument are quite different. Compressed air from the reservoir or air pump passes through the pipe A to the chamber B, thence, if the double valve a b is open, it will pass out through the pipe C to the chamber V. Its pressure then causes the end X′ of the lever X′X to move downward. This lever is connected to the damper in such a manner as to close off the supply of heat when in the position shown. If the room becomes too cold, mechanism to be hereafter described moves the valve a b into such a position as to close the communication to the compressed air in the chamber B and open communication with the atmosphere at a. This permits the air to escape from the chamber V, through the pipe C and opening b into the air, the diaphragm in the lower part of the chamber V being moved upward by a spring or weight not shown in the sketch. Thus it is seen that by moving the double valve a b the chamber V is put in communication with the compressed air and the damper moved to close off the heat, or with the outside air, in which case the pressure in the chamber V is lessened and the damper is moved by action of a weight or a spring so as to admit the warm air.

The mechanism for moving the valve a b consists of a thermostat T, which may be made of any two materials having a different rate of expansion, as rubber and brass, zinc and brass, etc. Connected to the thermostatic strip is a small valve K, so adjusted that when the room is too warm the valve will be opened and when too cold it

will be closed by the expansion and contraction of the thermostatic strip. Suppose the room too warm, and the valve K open, air then flows through the chamber B, through the filtering cotton in the lower part to B′, thence through the small tube d to the air, through the valve K. The small tube d connects with an expansible chamber D and opens back of a small diaphragm. When the valve K is open the spring S forces the diaphragm into the contracted or collapsed position, causing the lever G F to draw the valve a b so as to put the chamber B in communication with chamber V and cause the pressure to close the damper connected to the lever X′X. If, however, the room becomes too cold, the thermostat T moves so as to close the valve K; this stops the escape of air from the pipe d and causes pressure under the diaphragm at D to move the lever F G so as to move a b to the left, thus cutting off the supply of compressed air from the chamber V and permitting the air to escape at b. It will be noted that air is continually escaping at K during the time the room is too hot, but this is a very short interval as compared with the entire time and, moreover, the orifice at K is exceedingly small, so that the loss of air is quite insignificant. It will also be noted that with this apparatus the damper is quickly moved from a position fully open to that of being completely shut, or vice versa, and that it will not stand in an intermediate position fully open or fully shut. Since the installation of the apparatus described the manufacturers have commenced to manufacture a thermostat which moves the damper slowly and will hold it in an intermediate position, but this thermostat was not used at the date of the test and will not further be referred to here. One of the objects of the test was to determine the effect on the occupants of a room of quickly opening and closing the dampers.

In the actual construction of the thermostat the lever F G is a compound lever connected with a spring, so as to open and close the valve a b rapidly. In the slow moving regulator the valve a b is connected directly to the thermostat, so that it changes its position slowly, corresponding to change of temperature in the room, and produces a correspondingly slow change in the damper connections X′X. The apparatus as described is ingenious, simple, and has proved extremely satisfactory, keeping the temperature constant within a range generally of less than two degrees. No electric batteries need to be maintained, as in the older systems of temperature regulation.

In order to lessen the effect of suddenly admitting either tempered or warm air the architect arranged the damper so that it would not fully close the warm air pipe, so that in all cases a certain amount of

warm air would enter. This, as will be seen later, proved detrimental, since it interfered with the action of the thermostats by admitting warm air during the time the room should be cooling, and has been changed in most of the rooms since, so that the dampers fully close off the supply of warm air. Since this change the temperature regulation has been in every respect satisfactory.

Air and Steam Piping.—All air pipes leading from the fans to the bases of the flues are constructed of galvanized sheet iron. The warm air pipe is covered with a thin sheeting of asbestos. Both the heating and tempering coils are piped so that either the exhaust steam from the engines can be passed into them, or live steam from the boilers, or both together. All steam pipes are placed in exposed positions, so as to be readily accessible, and all are well covered with a non-conducting covering. All pipes for condensed steam are placed in brick ducts beneath the basement floor, and with the exception of the drips which are lead to the sewer, are connected with the receiver, so that the condensed steam will flow into it by gravity. Before entering the receiver the return mains, of which one is from the fan coils and the other two from the radiator system, are carried vertically to a height of about 30 inches above the floor in order to form a water seal for the steam in the coils and the radiators.

The apparatus for returning the condensed steam to the boilers consists of a receiver and feed pump, with governor. The supply of steam which operates the pump is controlled by a valve and float in the receiver. As the condensed steam from the fan coils or radiators falls into the receiver the float rises and, acting upon the valve, causes it to admit steam to the pump, which immediately feeds the hot water to the boilers without allowing it to cool. As the water level in the receiver falls, the float is lowered and the speed of the pump decreases. In this way it automatically supplies to the boiler any water entering the receiver. The pump exhausts into the atmosphere.

Outline of Investigations.—In undertaking these investigations it was our purpose to determine the amount and distribution of energy supplied the system in the coal burned, and to learn, if possible, where and how this distribution might be improved. For this purpose efficiency tests were made of the boilers, engines, and fans, and the energy consumed in the various parts of the system computed. To determine the efficiency of the boilers careful measurement was made of the coal supplied, ashes removed, water evaporated, pressure and temperature of the feed water, flue, and furnace. For the engine tests two all-day runs were made under normal conditions, one to determine the friction load of each engine and another to determine the average water rate.

For the fans two all-day tests were made; investigations were undertaken to determine at what positions in a cross section of the discharge pipes a fair average sample of air as to both the temperature and velocity could be obtained. Investigations were also carried on to determine whether any greater convenience was found or any saving of fuel would result from placing dampers in the exhaust or eduction flues from each room, which might be closed during the night when there was no particular need for ventilation. The tests also undertook:

(1.) To determine the relation of the coal consumption of the plant to the outdoor temperature;

(2.) to determine the distribution of the heat in rooms Nos. 5 and 6 by placing thermometers at various points in them and noting the temperatures at these points under various conditions;

(3.) to determine the distribution of the air by noting its direction and velocity after leaving the induction flue, and

(4.) to determine the range of action and adjustment of the thermostat in room No. 8.

Preparation for Testing.—In order that the boilers might be tested under as nearly normal conditions as possible it was necessary to measure the condensed steam from the coils and radiators in such a way that it could be returned to the boilers without any additional loss of the heat which it contained. To effect this it was measured in the receiver adjacent to the pump; this had been previously calibrated by pouring down weights of water into it and noting the level corresponding to different weights in the gauge glass on one end of the receiver.

The method of measuring the water on Feb. 25, '97, was as follows: The float valve within the receiver was disconnected, so that the pump could only be started and stopped by a valve in the steam pipe. Water from either the radiator system or the fan system was then allowed to collect in the receiver by opening the necessary valve in the three vertical return pipes. When nearly full this valve was closed, the scale reading on the glass noted and the pump started, thus emptying the receiver and supplying the boiler. The pump was then stopped and the scale reading again noted, after which the receiver was allowed to fill. In the same way all cold water supplied the boilers to make up the loss due to drips, leakage, and the pump exhausting into the air, was run into the receiver and measured, then pumped into the boilers.

The temperature of the condensed steam from the fan heaters and radiators and of all water fed to the boilers was obtained by a thermometer inserted in the discharge pipe from the pump and at a

distance of about six inches from it. A thermometer was placed in each boiler flue to determine the temperature of the flue gases, and a water manometer was attached to each flue to determine the draft. The temperatures and pressure of the air discharged from the fans was obtained in a similar way by placing thermometers and tubes connected with water manometers in the air pipes from each.

Each engine was provided with a reducing motion, which was attached to a rod fastened to the cross head and projected through a slot in a board which was put on in place of the regular cover, which was necessary because of the air tight casing provided with the engine. For the small engine a pantograph was used and for the large engine a modification of the pendulum. Each cylinder was piped and fitted with a three-way cock to accommodate a Calkin's indicator. A throttling calorimeter was placed in the main steam pipe of the large engine, just above the throttle valve. From the similar arrangement of the two engines on either side of the steam main from the boilers this determination of the quality of the steam supplied by the boilers was considered sufficient for both.

For the experiments in connection with the exhaust flues from the different rooms paste-board covers, over a light frame work of wood, were made and these were placed over the top of each flue from the roof.

In connection with the work in room No. 8, after the data on March 13 and 16 had been obtained, the mixing damper at the base of the flue was altered, so that either the warm air or the tempered air could be shut off entirely instead of as in the original dampers, arranging so that at all times part of the warm air would be flowing through. This was done in order to experiment with a new thermostat, which was designed to keep the damper floating, or to shut off either the warm air or the tempered air entirely.

It may be mentioned that previous to the test described a test for capacity of fans had been made. This test showed that the capacity of the fans was much in excess of the requirements of the building, and that, if necessary, the air could be changed in any room in six minutes of time. The capacity of the pipes was adjusted by permanently fixed adjusting dampers, so as to give each room its proper supply of air; for this reason no capacity test is included in this report.

Boiler Trial.—The boilers, two in number, are of the horizontal tubular type, with full cast iron fronts. Each one is 14 feet long by 60 inches in diameter, has 76 3-inch tubes, and is provided with a rocking grate 54 by 60 inches, and a lever safety valve. The shell is of steel 11-32 of an inch thick, with heads 7-16 of an inch. Steam

DATA AND RESULTS OF BOILER TEST.

1	Number of boilers		2
2	Duration of trial in hours		13.0
	DIMENSIONS.		
3	Water heating surface in each boiler	Sq. Ft.	1030
4	Length of grate	Inches.	54
5	Width of grate	"	60
6	Area of grate	Sq. Ft.	22.5
7	Relation of water heating to grate surface		45.8
8	Height of stack above grate	Feet.	66.
9	Area of stack	Sq. Ft.	8.03
10	Ratio of stack area to total grate surface		.357
	AVERAGE PRESSURES.		
11	Barometer	Lbs.	14.36
12	Steam gauge	"	23.3
13	Draft	Inches of water.	.065
	AVERAGE TEMPERATURES.		
14	External air	Degrees F.	35.1
15	Boiler room	"	67.
16	Flue	East–West.	236–242
17	Furnace	" "	2313–2830
18	Feed-water		146.
19	Total coal consumed	Lbs.	1000.
20	Moisture in coal	Per Cent.	4.17
21	Dry coal consumed	Lbs.	958.
22	Total refuse dry	"	170.
23	" " "	Per Cent.	17.8
24	" combustible	Lbs.	788.
25	B. T. U. per pound coal from analysis		12450.
27	Quality of steam	Per Cent.	98.41
	WATER.		
28	Total weight of water used	Lbs.	8768
29	" evaporated dry steam	"	8630
30	" " from and at 212°	"	9390
31	" " " feed water 100° to steam at 70 pounds by gauge	Lbs.	8300
	ECONOMIC EVAPORATION.		
32	Water actually evaporated per lb. dry coal	Lbs.	9.16
33	Equivalent from and at 212°	"	9.8
34	" per lb. combustible	"	11.9
	RATE OF EVAPORATION.		
35	Water evaporated per hour per Sq. Ft. of heatiug surface.		.655
36	Per Sq. Ft. of grate surface		30.0
37	Equivalent evaporation per hour per Sq. Ft. of heating surface		32.15
38	Per Sq. Ft. of grate surface		32.15
	RATE OF COMBUSTION.		
39	Dry coal burned per Sq. Ft. of grate surface per hour		3.28
	HORSE POWER.		
40	Total horse power on a basis of 30 Lbs. water evaporated from feed water 100° to steam at 70 Lbs.		21.3
41	Builder's rating for each boiler		70
42	Heat supplied per hour from coal as per analysis, B.T.U.		1918000
43	Heat absorbed per hour		1395000
44	Efficiency of boilers, (44 ÷ 42)	Per Cent.	72.5

ANALYSIS OF COAL:	Moist Coal.	Dry Coal.
Moisture, per cent	4.17	0
Volatile Matter, per cent	13.91	14.51
Carbon	65.37	68.21
Ash	16.56	17.28
B. T. U., per pound, by Calorimeter	12450	....

Kind of coal, anthracite buckwheat.

is drawn from a dry pipe instead of a dome for which there was insufficient head room.

A regular boiler trial, the log and data of which will be found on the following pages, was made on Feb. 25, in connection with a test of the engines and fans. On account of the difficulty of measuring the return water from the radiators in the operating shed, which did not discharge through the trap back of the boilers, but was returned directly, the boiler test was conducted only for such a time as the steam could be closed off from the operating shed.

From the data taken on this test it appears that the boilers are worked very much below their capacity. This is probably due largely to the low steam pressure carried. The natural draft is very

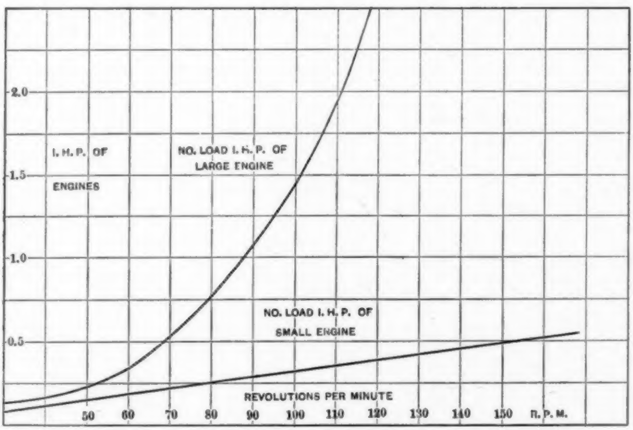


FIG. 12.—FRICTION OF ENGINE. HORSE POWER FOR VARIOUS SPEEDS.

low, but when both boilers are in use it is usually sufficient. By using a steam jet to force the draft one boiler will usually supply all the steam needed, except, perhaps, in the very coldest weather.

ENGINE TRIALS.—The engines are of the enclosed horizontal type non-condensing and running in oil. The large engine has a cylinder 15 inches in diameter and an 8-inch stroke. At 20 pounds steam pressure and 150 revolutions per minute it is designed to give 19 indicated horse power. It is provided with two fly-wheels, each 48 inches in diameter and 10½ inches face. The small engine has a cylinder 6 by 8 inches and is designed for a much higher steam pressure. It has fly-wheels 40 inches in diameter and 7½-inch face. Both engines have automatic shaft governors operating on piston valves.

Two all-day engine trials were made to determine the power taken by the engine and to drive the fans. The log and data of these will be found on the following pages. A run was made to determine the water rates of the engines by supplying the heating coils of the system with only the exhaust steam from the engines and measuring the condensed water for the given time. Since both engines discharge into the same pipe and from this pipe the exhaust steam is taken into each heater coil of both fans, it was impossible to get the water consumption of each engine individually; that given was obtained by dividing the total steam condensed by the average total I. H. P. for the given time.

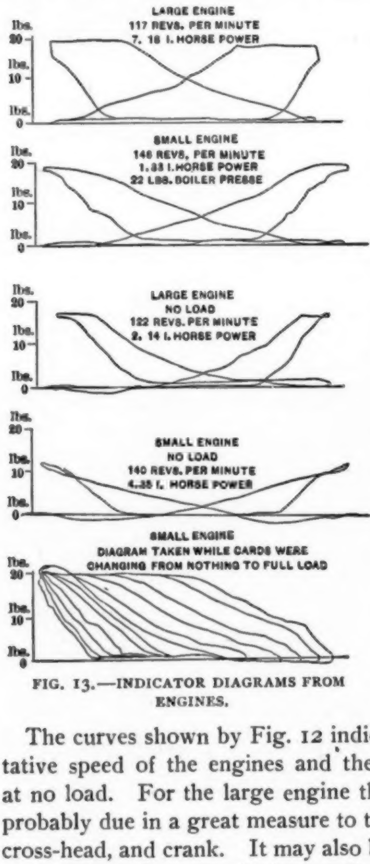


FIG. 13.—INDICATOR DIAGRAMS FROM ENGINES.

This result gives a water rate (weight of steam per I. H. P. per hour) which is probably too low for the large engine and too high for the smaller one, the high water rate in both, no doubt, being due largely to the low steam pressure, which is augmented in the large engine by the unusual portions of the cylinder and low rotative speed and in the smaller engine by the early cut-off, as shown by the specimen cards in Fig. 13. To determine the friction of the engines, cards were taken with the engines running at different speeds and with the belts off.

The curves shown by Fig. 12 indicate the relation between the rotative speed of the engines and the power required to drive them at no load. For the large engine this seems to be excessive and is probably due in a great measure to the bad condition of the cylinder, cross-head, and crank. It may also be partly due to the short stroke.

On Figs. 18 to 23 will be found curves showing the variation of the I. H. P., D. H. P., and R. P. M. of the engines at different times during the two all-day runs. This variation is much greater for the large engine than for the small one.

The form of indicator diagrams is shown in Fig. 13 for various loads and for each engine. The diagrams show some back pressure, but otherwise are very good and indicate good steam distribution.

Fan Trials.—The fans are of the regular steel plate type built by the Buffalo Forge Co. See Fig. 14 for view of fan removed from casing and Fig. 15 for view of engine and fan connected. The large one has a casing 120 inches in height and a fan 84 inches in diameter, with blades arranged radially and mounted on a single spider having a cast iron hub and T-iron spokes. These blades have their outward edges bent backward in a circular arc against the direction of rotation and are firmly held together on the sides by two parallel concentric bands of sheet iron equal in width to the depth of the blade. They are 30 inches wide across the outer edge and taper to 36 inches across the inner edge. They are 14½ inches deep. The driving pulley is 30 inches in diameter and ten inches across the face. The small fan is of the same type as the larger one. It has a casing 60 inches high and a fan 44 inches in diameter. The blades

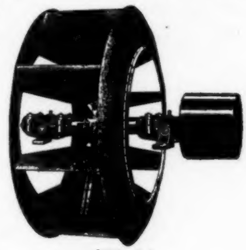


FIG. 14.

FIG. 15.—DOUBLE DUCT FAN SYSTEM APPARATUS

are 15½ to 21½ inches in width and six inches deep. The driving pulley is 20 inches in diameter and six inches across the face. Both fans draw in the air through circular openings at the center of the casing on opposite sides to the driving pulleys. The large fan has

an opening 54 inches in diameter and the small one 26 inches. In the large fan the outlet is at the bottom, in the small one at the top, and the sizes of these openings are respectively 40 by 42 inches and 22 by 22 inches.

The heaters for each fan consist of five sections, of which four are placed in each warm air pipe, and the one called the tempering coil

TABLE II.

STEAM CONSUMPTION OF ENGINES FROM TEST, MARCH 20, 1897.—SUMMARY OF RESULTS.

No.	Time.	Large Engine.		Small Engine.		Boiler Pressure Gauge.
		Revs. Per Min.	Ind. H. Power.	Revs. Per Min.	Ind. H. Power.	
	Hrs. M.					
1	2-35	108	5.41	145	1.33	21.2
2	2-53	112	6.31	148	1.42	21.4
3	3-10	112	6.67	146	1.35	22.2
4	3-25	114	6.30	148	1.35	22.6
5	3-40	114	6.55	148	1.58	22.7
6	3-55	114	6.71	148	1.66	23.
7	4-10	112	6.36	146	1.55	23.
8	4-25	114	6.41	148	1.60	23.2
Average..........................			6.31		1.48	

Total indicated horse power, both engines, 7.82.
Total steam used by both engines, per hour, 642.5 lbs.
Steam per indicated horse power, per hour, average, 82.2 lbs.

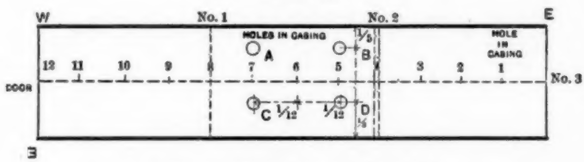
FRICTION OF ENGINES, FEB. 25, 1897.—ENGINES RUNNING LIGHT AND WITH BELTS OFF.

No.	Large Engine.		Small Engine.	
	Revs. Per Minute.	Ind. Horse Power.	Revs. Per Minute.	Ind. Horse Power.
1	54	0.259	83	0.292
2	65	0.310	88	0.252
3	64	0.457	116	0.336
4	74	0.706	120	0.360
5	73	0.634	140	0.435
6	80	0.415	14)	0.420
7	80	0.399	150	0.516
8	92	1.079	148	0.476
9	93	1.355	150	0.490
10	103	1.61	...	....
11	105	1.66	...	....
12	110	2.10	...	....
13	112	2.13	...	....

is placed in the current of air entering the fan. For the large fan each section is six feet long by six feet ten inches high and is built of four rows of wrought iron pipe screwed into a cast iron base. The total heating surface of the five sections is 4,770 square feet. For the small fan each section is built in the same way as for the large fan and is three feet long by five feet ten inches high, giving a total heating surface for the five sections of 1,980 square feet.

In making a test of the fans the velocity of the air forced into the pipes was measured by an anemometer placed in each pipe through a small door. It having previously been found that the currents varied in different parts of a cross section of the pipe, the instrument was held, as nearly as possible for each reading, in that position in the pipe which had previously been determined as giving a fair average velocity. (See special experiment). In like manner the temperature of the air leaving the fans was obtained by placing thermometers in the pipes.

TABLE III.



VERTICAL SECTION OF HOT AIR PIPE.

VARIATION IN TEMPERATURE IN WARM AIR PIPE.

No. on Center Line.	Variation from East to West.				Variation from Bottom to Top.				
	Temperatures above and below Center Line.				Dis. from Bottom. Inches.	Temp. under No. 1.	Dis. from Bottom. Inches.	Temp. Under.	
	1	2	3	4				No. 1.	No. 2.
1	83	..	73°	..	1	69°	1"	82°	86°
2	82	..	76	76	4	77	2	88	84
3	84	83	74	76	6	82	5	94	89
4	85	83	75	75	8.5	94	8.5	97	85
5	87	84	82	81	12	106	10.5	116	85
6	95	90	97	98	14	112	12	124	86
7	96	94	95	81	17	118	14	128	90
8	78	76	80	80	19	116	16	131	85
9	78	84	81	80	21	96	18	129	85
10	84	80	82	80	24	73	19	128	85
11	70	..	82	..	27	66	21.5	116	83
							23.5	93	85
							27	76	85
Average	83 8	84.2	81.5	80.8	..	91.8	..	108	85.6

The temperature of the air supplied the fans on the first trial was taken as the out-door temperature of the air; on the second trial it was measured by a thermometer in each cold air room. The log and data from these trials will be found on diagrams 17 to 23.

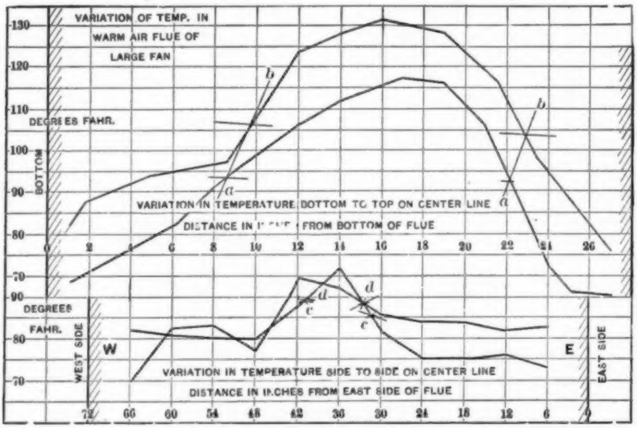
The efficiencies of the fans tabulated seem at first very low, but when it is considered that the fan is required to draw the entering air through the tempering coil, between four rows of closely spaced steam piping, and then force a large part of this same air through the heater between 16 rows of pipe, in addition to overcoming the

resistance occasioned by two sharp bends in each discharge, it is believed to be a reasonable quantity.

The delivered horse power (D. H. P.) of the engine was obtained by subtracting the friction horse power of the engine for the given speed from the indicated horse power (I. H. P.). The D. H. P. of the fan was computed from the foot-pounds of energy delivered to the air. The latter divided by the former gives the efficiency of the fan.

The number of British thermal units given to the air by the fan system were computed by multiplying the total weight of air delivered by the fan at each reading by the specific heat of the air and

⅓ FROM BOTTOM. 11.5 FROM TOP.



MEAN $\frac{1}{12}$ EITHER SIDE OF CENTER.

FIG. 16.

by the degrees of difference in temperatures between the cold air supplied the fan and the tempered air delivered by it. To this was added the B. T. U. obtained by multiplying the weight of air passing through the warm air pipe at each reading by its specific heat and by its difference in temperature above that of the tempered air. In the first test, on Feb. 13, the B. T. U. given to the air passing through the tempered and warm air pipes of the large fan were computed, using the average all-day temperatures of the air in these pipes. This was checked later by the investigation to determine the average reading in the warm air pipe, as explained.

The curves on diagrams 18 to 23 show the variation in the weight of air delivered, the D. H. P., and the revolutions per minute of each fan for different conditions, plotted on a vertical line which represents the time when the observations were taken. From these it

will be noticed that as the speed increases the weight and efficiency increase approximately. If the readings could have been taken simultaneously it is probable that this would be shown more clearly.

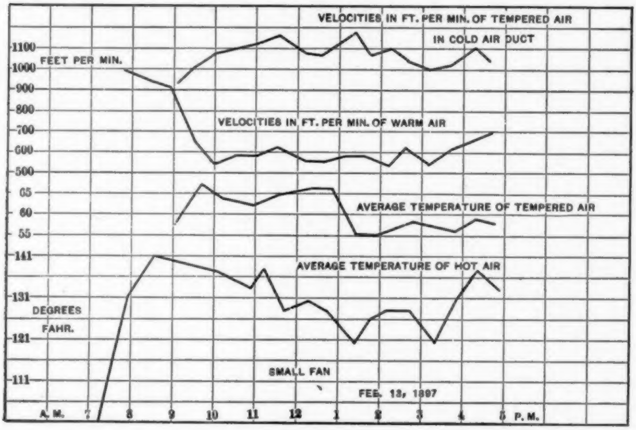


FIG. 17.—GRAPHICAL LOG SHOWING VELOCITY AND TEMPERATURE OF AIR, FEB. 13, 1897, SMALL FAN.

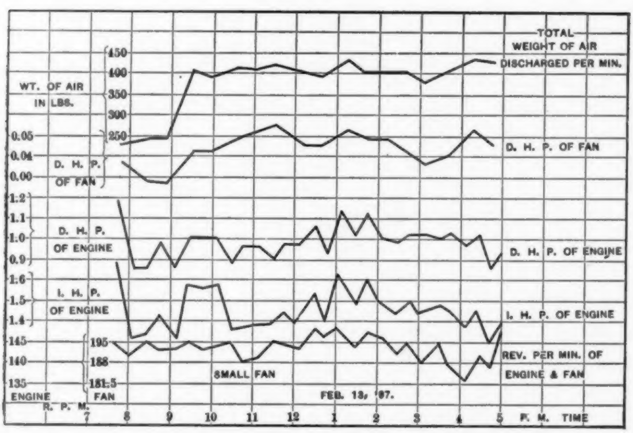


FIG. 18.—GRAPHICAL LOG SHOWING SPEED, HORSE POWER, AND WEIGHT OF AIR, SMALL FAN.

Diagrams on Figs. 17, 19, and 22 show curves representing the variations in the velocities and temperatures in the warm and tempered air pipes. From these it will be seen that, in general, as the

velocities through the former increase the temperature decreases; the same is also true in the tempered or cool air pipe. On Fig. 24 are plotted curves showing the average temperature of the building

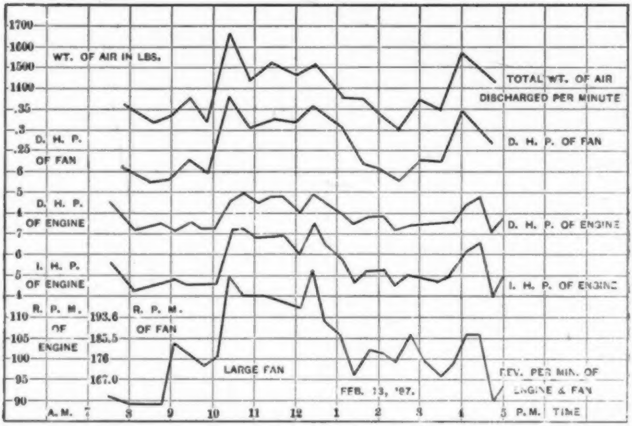


FIG. 19.—GRAPHICAL LOG SHOWING SPEED, HORSE POWER, AND WEIGHT OF AIR, LARGE FAN.

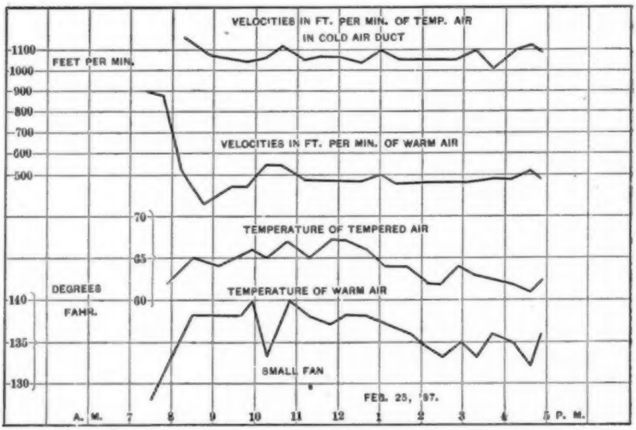


FIG. 20.—GRAPHICAL LOG SHOWING VELOCITY AND TEMPERATURE OF AIR, SMALL FAN, FEB. 25, 1897.

during the day, the B. T. U. sent to the rooms per minute, and the temperature in the cold air chamber of each fan. From these it will be seen that after the building reaches its normal temperature the

thermostat maintains the average nearly constant, the variation being only about one degree, the temperature decreasing slightly as the heat supplied decreases. The temperature in the cold air room

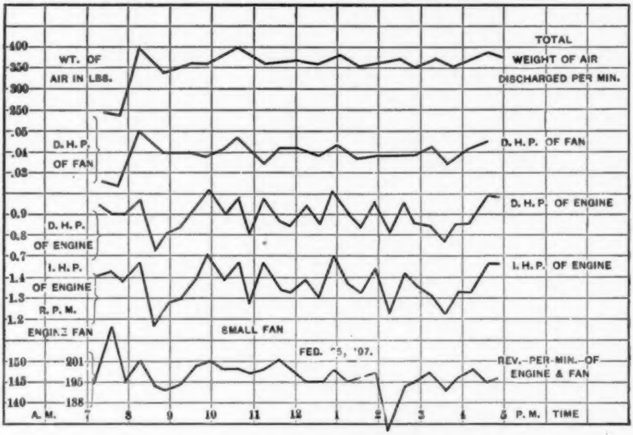


FIG. 21.—GRAPHICAL LOG SHOWING SPEED, HORSE POWER, AND WEIGHT OF AIR, SMALL FAN.

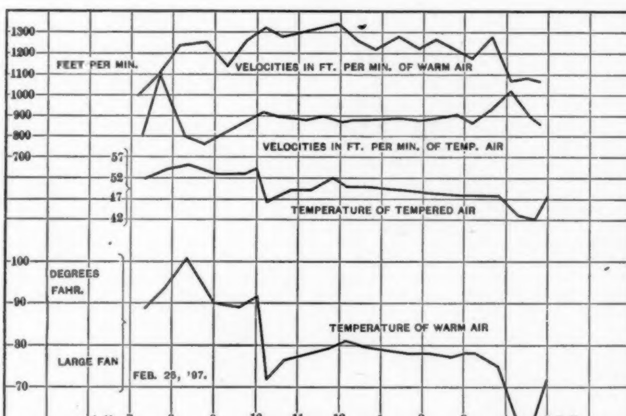


FIG. 22.—TEMPERATURE AND VELOCITIES OF AIR, LARGE FAN, FEB. 25, 1897.

of the large fan follows closely the outdoor temperature, while in the cold air room of the small fan it is considerably higher, owing to a part of the supply being drawn from the museum in the story above.

The curves on Fig. 24 are of extreme interest, as they show, first, the increase in the temperature of the building when heat is turned on; second, the amount of heat required to maintain the temperature

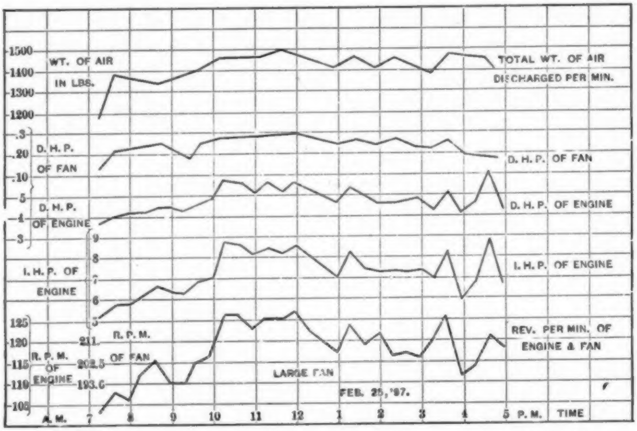


FIG. 23.—SPEED, HORSE POWER, AND WEIGHT OF AIR, LARGE FAN, FEB. 25, 1897.

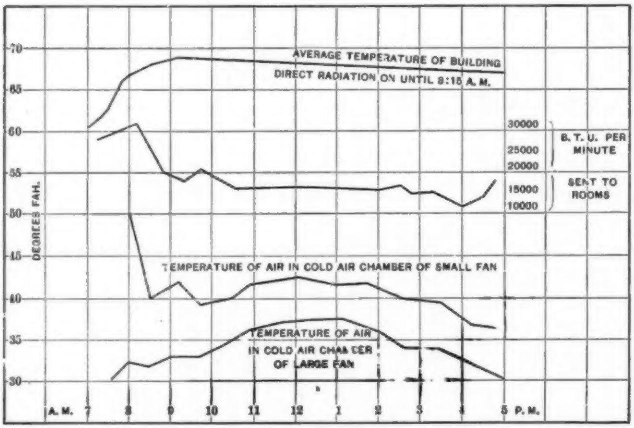


FIG. 24.—GRAPHICAL LOG SHOWING CHANGE OF TEMPERATURE IN BUILDING AND HEAT GIVEN OFF, FEB. 25, 1897.

constant; third, the outside temperature, which corresponds to the lower line.

VARIATION IN TEMPERATURE IN HOT AIR PIPES.—Some pre-

liminary measurements of temperature taken with thermometers in different positions showed a great variation in different portions of the cross section, the range of temperature varying from 82 at bottom to 131 at center to 76 at top on one trial and from 68 to 116 to 65 on another; and from 70 on one side to 95 at center to 83 on further side. These observations are shown in Table III, and in diagram in Fig. 16, and the observations show that a temperature very near the average is found at a point about one-third distant from the bottom, or again at a point one-fifth the distance downward from the top and to right or left of center line a distance equal to 1-12 the breadth of the pipe. These points are denoted by A, B, C, and D on diagram at head of table of temperatures. For the pipe in question,

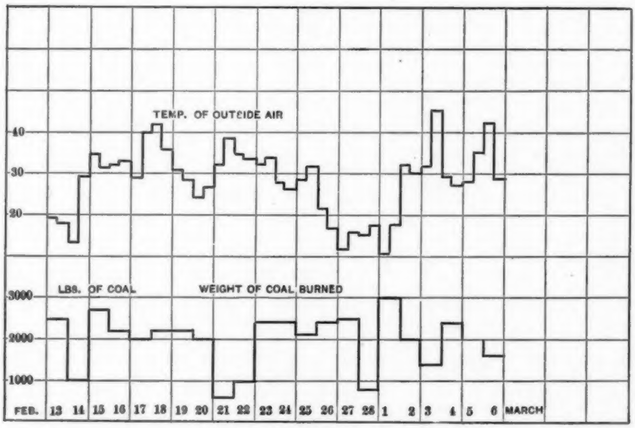


FIG. 25.—GRAPHICAL LOG OF COAL BURNED FROM FEB. 12 to MAR. 7, 1897.

which was 72 by 28 inches, average temperature points were found 9.33 inches from bottom, 5.6 inches from top, and right and left of center at distance of six inches. The average temperature was fully 25 per cent less than the maximum obtained by measurement at the center and serves to show the magnitude of errors that might be made by using center readings as correct.

BUILDING LOSS.—From this data we can compute the heat required to supply the building loss; thus, at 12 noon, the temperature in the building is about constant at 68 degrees F., and 1,600 B. T. U. are required per minute. By examining previous graphical logs we find at this time that the large fan is delivering per minute 1,475 pounds of air, which is warmed from 34 to 80 degrees F. The small fan is delivering at the same time 365 pounds raised from 42 to 136

degrees. The amount of heat entering is proportional to $1475 \times 46 + 365 \times 94 = 102060$. The amount of heat discharged in ventilation flues is proportional to $1475 \times 13 + 365 \times 58 = 39290$ or nearly 39 per cent. Of the total supplied at this time 61 per cent (100 — 39) must have escaped through the walls and windows; 61 per cent of 16,000 is equal to 9,150 per minute or 549,000 B. T. U. per hour. The building has 9,281 square feet of glass and 31,644 square feet of exposed wall surface; in accordance with foreign experiments quoted at length in a book on heating and ventilation by the author, it is shown that the building loss per hour can be taken closely at one B. T. U. for each square foot of glass and one-quarter as much per each square foot of wall, for each degree difference in temperature. In accordance with that law we should lose 7,911 B. T. U. from the walls and 9,281 B. T. U. from the glass for each degree difference of temperature. The difference of temperature is $78 - 36 = 31$ degrees. Multiplying 17,192 ($7{,}911 + 9{,}281$) by 31 we have as a product 532,952. That is, the heat loss from the building differs by less than two per cent from the rule as enunciated above, and hence we can consider this case as a verification of the rule cited, and it would also seem to prove correct for average cases. The building loss per hour in heat units is equal very closely to the product of difference of temperature, into area of glass in square feet plus one-fourth the area of exposed wall. The writer may call attention to another experiment cited in a paper at last annual meeting of the society.

The following tables give the efficiency and capacity of the fans as determined by measurements of velocity, temperature, and pressure of the air.

Efficiency from Steam Used.—The amount of heat absorbed by the air must in every case be sensibly equal to that given up by the steam and hence may be determined by an entirely independent test made by weighing the amount of steam condensed, deducting from this weight the heat carried off in the condensing water, and correcting the results for moisture in the original steam. In connection with the tests of the building the amount of steam condensed was measured, the results being given in Table V.

The measurements of the steam can be made with considerable accuracy, but those of both velocity and temperature of air are made with difficulty; by comparing the results of the two methods of testing it would seem probable that the measurement of air or of the average temperature made in the test of Feb. 13 was about 16 per cent in excess. The measurement of Feb. 25, however, seems to have been very nearly correct, as the results agree within probable errors of either kind of testing. The distribution of the heat as

TABLE IV.

EFFICIENCY OF FAN.—MEASUREMENTS OF AIR, TEST OF FEB. 13.

	Large Fan.		Small Fan.	
	Tempered Air.	Warm Air.	Tempered Air.	Warm Air.
Velocities, average feet per minute	1400.	1000.9	1186.	601.
Temperatures, degrees F.	48.2	98.	59.5	130.2
Volume, cubic feet per minute	8660.	11708.	3332.	2530.
Volume at 70° F. and 14.7 pounds pressure	7920.	11092.	3322.	2140.
Weight per minute, pounds	588.	833.	249.2	160.6
Foot pounds per second, ½ MV²	82.2	61.4	21.05	4.24
Pressure above atmosphere, inches of water	0.283	0.198	0.104	0.106
Barometer reading, pounds	14.48	14.48	14.48	14.48

	Large Fan.	Small Fan.
Total weight of air moved, pounds, per minute	1421.	384.
Foot pounds, per second	143.6	23.9
Horse-power of fans	0.261	0.043
D. H. P. of engine	3.94	0.992
Efficiency of fan, average, per cent	6.63	4.38
Average out-door temperature	19.	19.
B. T. U. to tempering coils, per minute	9783.	3043.
B. T. U. to heater coils, per minute	9733.	2771.
Total B. T. U., each fan	19518.	5814.

	Inches.	
Dimensions of flues—		
Tempered air	40 x 20	42. x 10.5
Warm air	72 x 28	41.5 x 14.25
Area of flues, square feet—		
Tempered air	5.56	3.06
Warm air	11.66	4.04

EFFICIENCY OF FAN.—MEASUREMENTS OF AIR, TEST OF FEB. 25.

	Large Fan.		Small Fan.	
	Tempered Air.	Warm Air.	Tempered Air.	Warm Air.
Velocities, average feet per minute	888.	1218.	1073.	411.
Temperature in degrees F.	49.7	80.6	64.5	135.
Volume, cubic feet, per minute	4835.	14150.	3321.	1915.
Volume at 70° F. and 14.7 pounds pressure	4975.	13630.	3246.	1675.
Weight per minute, pounds	376.	10017.	243.5	125.3
Foot pounds per second, ½ MV²	21.5	110.	20.3	2.07
Pressure above atmosphere, inches of water	....	....	0.116	0.1
Barometer reading, pounds	14.6	14.6	14.6	14.6

	Large Fan.	Small Fan.
Total weight of air moved, pounds, per minute	1394.	354.8
Foot pounds, per second	131.5	21.58
Horse-power of fan	0.24	0.039
D. H. P. of engine	4.8	0.90
Efficiency of fan, per cent	5.2	4.38
Average out-door temperature	34.	34.
B. T. U. to tempering coils, per minute	5170.	1950.
B. T. U. to heater coils, per minute	7456.	2296.
Total B. T. U., each fan	12630.	4246.

EFFICIENCY OF FAN.—MEASUREMENT OF AIR.

	Large Fan.		Small Fan.	
	Tempered Air.	Warm Air.	Tempered Air.	Warm Air.
Velocities, average feet per minute	623.	1168.	1283.	605.
Temperatures, degrees F.	60.	91.5	63.	100.
Volume, cubic feet, per minute	3460.	13648.	3925.	2445.
Volume at 70° and pressure 14.7 pounds	3455.	12850.	3900.	2265.
Weight per minute, pounds	258.5	965.	292.	169 6
Foot pounds per second, · · MV^2	7 22	94.5	34.55	4.45
Barometer reading, pounds	14.4	14.4	14.4	14.4

	Large Fan.	Small Fan.
Total weight of air moved, pounds, per minute	1223.5	461.6
Foot pounds, per second	101.7	39.0
Horse-power of fan	0 185	0.071
Indicated Horse-power of engine (I. H. P.)	6.34	1.48
Delivered Horse-power of engine (D. H. P.)	4.2	1.46
Efficiency of fan, per cent	4.4	4.83
Average out-door temperature, degrees	56.	56.
B. T. U. given by tempering coil, per minute	1167.	768.
B. T. U. given by heater coil, per minute	7230.	1492.
B. T. U., tempering coil, per square foot per hour	72.5	116 2
B. T U., heating coil, per square foot per hour	114.	56.5

TABLE V.

HEAT MEASUREMENTS FROM STEAM CONDENSED.

	Feb. 13.	Feb. 25.
Duration of tests	10 hs., 10 m.	10 hs., 10 m.
Total steam condensed in both fan coils, pounds	13560.	106~4.
" " " in direct radiators, pounds	1013.	680.
" cold water supplied boilers, pounds	2350.	1667.
" used by pump and leakage, pounds	1279.	1097.
" drips from operating shed, pounds	1071.	570.
Steam condensed in fan coils per minute, pounds	22.22	17144.
" condensed in radiators per minute, pounds	1.126	9.07
" used by pump per minute, pounds	2.1	1.83
Average boiler pressure, pounds	23.	23.3
" quality of steam, per cent	98.5	98.4
B. T. U. per pound of steam supplied	1178.	1178.
Average temperature of condensed steam from fan coils, degrees F.	182.8	169.5
" " " " from radiators, "	162.5	120.
B. T. U. to fan coils and engines, per minute	22110.	17588.
B. T. U. to engines, per minute	300.	365.
B. T. U. to fan coils only, per minute	21810.	17223.
B. T. U. to direct radiators, per minute	1145.	960u.
B. T. U. in air from fans, as per previous tables, per minute	25332	16876.
Difference in two tests B. T. U.	+3522.	—347.
Difference, per cent	16.2	2.

determined by a portion of the test of Feb. 25 was made by Messrs. Noe and Hulett, and is given in Table VI.

DEDUCTIONS FROM THE TESTS.—It is noted from the previous description that the heating plant provided is unnecessarily large, and there is little doubt but the fans would have shown a much higher efficiency could they have been operated at a somewhat higher speed. The fan efficiency is very low and not essentially different from five per cent. It will be noted, however, that the exhaust steam of the engines is used for heating the building, and hence no actual loss is experienced during the heating season by

this low efficiency. The case is otherwise, however, during the warm weather, when ventilation is required but heat is not needed.

TABLE VI.—HEAT USED IN WARMING BUILDING, FEB. 25, 1897.—
7 A. M. TO 1.25 P. M.

Total steam condensed in both fan systems	Lbs.	7157
" " " Radiators, main building	"	680
" " used by pump	"	758
Steam condensed in fan coils per min	"	18.6
" " " radiators "	"	1.75
" used by pump	"	1.96
Temperature of water from fan coils	Degs.	169.5
" from radiators	"	120
" cold water fed to boilers	"	54
B. T. U. in steam from boilers, per lb.		1173
B. T. U. supplied per minute in coal		31965

DISTRIBUTION OF LOSSES.

	B. T. U. Per Min.	Per Cent.
Loss of heat in boilers	8605	27.2
Friction losses in engines (I. H. P.—D. H. P.)	124	0.388
Friction fans and belts (I. H. P.—Friction.)	229.5	0.718
Moving air in both fans	11.44	0.0358
Heat used by pump	2200	6.9
Heat absorbed from both fan coils by air	18385	57.51
" " by radiators	1854	5.8
Total	31500	98.55

The heat absorbed by air from measurements of velocity and temperature was for the same time.

From small fan	4318 B. T. U.
From large fan	13690 B. T. U.

The above calculations account for all the heat excepting 1.45 per cent, and the close agreement of the measurements made of the heat carried off in the air by the condensed steam and also from its velocity and change in temperature would indicate extremely accurate results.

The question will arise whether it would not pay better to substitute electric for steam power for driving the plant during the summer months. Messrs. Noe and Hulett investigated this question and arrived at the following conclusion: Taking into account all the unfavorable conditions which have been enumerated, the following facts relating to this question were ascertained:

STEAM POWER.

Maximum I. H. P. developed by engine during two all-day runs	8.6
Maximum D. H. P. for above	5.7
Steam required by engines, 83 lbs. per I. H. P, for 6 hours	4263
Total steam required by pump, lbs.	560
Total steam required per day, 6 hours, lbs.	4783
Coal burned, assumed evaporation of 9 lbs. per day	532
Cost per day of coal at $2.50 per ton	$0.67
Estimates of cost of stopping, starting, oil, etc	$0.33
Total cost of steam power per day without attendance	$1.00

ELECTRIC POWER

H. P. required, motors 85 per cent efficiency	6.7
Amperes of current at 500 volts	10
Kilo-Watt hours per day of 6 hours	30
Cost per day, at 10 cents per Kilo-Watt hour	$3.00

In neither case is the cost of attendance considered. Under usual conditions this would be considerably more for the steam power, but under the conditions existing in the State Veterinary College

one man would be employed in either event, and even under most favorable conditions the saving could only be one-half a day's work for a man, which, at the wages paid here, would be 75 cents per day. If we consider the labor cost of operating the steam plant in the summer time as 75 cents per day more than that for the motor, the difference is still about 33 per cent in favor of the use of steam.

The use of direct driven water motors cannot with propriety be considered for this case, although it is readily understood that in many cases they would show a substantial saving for ventilation purposes over a steam engine.

THE EFFECT OF COVERING TOPS OF VENT FLUES.—The ventilation flues of the building are in every case chimneys with open tops and unprovided with dampers. It was believed, from the fact that these flues open directly into the various rooms from the outside air, that a considerable saving might be made by closing dampers at the time of closing the building for the night, and opening them in the morning. In making the experiments the tops of the vent flues through two registers, each ten feet from the floor and to the back were covered by placing hoods over the chimneys on alternate nights, noting the effect on the temperature of the room in the morning. It was found that a sensible saving could be produced by closing dampers at night only in those flues in the one-story wing attached to the main building. The saving was very doubtful and insensible for the main building. Table VII gives the average values of experiments with the chimney covered and uncovered.

RELATION OF COAL CONSUMED TO TEMPERATURE.—A test was also made covering a period from February 12 to March 7, during which time the coal was weighed day by day. These results are shown on the accompanying tables of results and also on the diagrams on Fig. 25. The latter show by diagram the weight of coal burned and the corresponding temperature of outside air drawn to a different scale, and located slightly above. There is a general correspondence in the form of the two diagrams, but it is frequently noticed that a change in the coal consumption may follow by one or two days the change of temperature in the outside air. A long period of warm weather is certain to reduce the coal consumption, although a single day seems to have little effect; this is due in a great measure to the amount of heat which is absorbed in the building.

VARIATION OF TEMPERATURE AND DISTRIBUTION OF AIR IN MAIN LECTURE ROOM NO. 5.—This room is 35½ by 36, by 20 feet high and has 135 seats in the auditorium, arranged semi-circularly in plan and also in tiers. It is supplied with hot or tempered air

TABLE VII.

EFFECT OF COVERING TOP OF VENTILATING FLUES ON MORNING TEMPERATURE OF THE MAIN BUILDING.

	Average Temp. of Building.	Temp. Outside Air.	Difference in Temp.	Velocity of Wind. Miles per Hour.	Direction of Wind.
February 23-24, with Covers...	65.5	27.6	37.9	14.6	N. W.
" 24-25, without " ...	67.6	28.4	39.2	8.54	S.
" 25-26, with " ...	63.8	21.9	41.9	9.5	N. W.
" 26-27, without " ...	63.45	11 72	51.73	5.1	N.
" 27-28, with " ...	65.5	15.22	50.28	8.4	S. E. & S.
March 1-2. without Covers.........	64.3	32.4	31.9	13.2	S. to N.
" 2-3, with "	66.7	31.6	30.1	6	N. to S.
" 3-4, without "	63.5	29.9	33.6	15	W.
" 4-5, with "	66.2	27.9	28.3	10.5	S. E.
" 5-6, with "	67.7	42.5	20.2	13.3	S. to W.
" 6 7, without "	64.3	16.6	47.7	6.4	N. W.

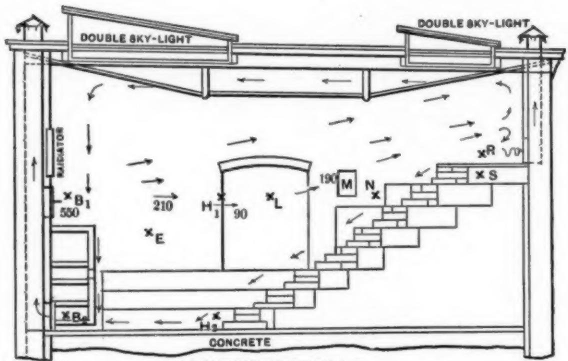
The saving was very marked in the one story wing, although of no importance in the three story main building.

The test on the wing is not given in the table.

LOG OF COAL BURNED FROM FEBRUARY 12 TO MARCH 7.

Date.	Average Temp. 12 Hours.		Weight of Coal. Pounds.	Weight of Ash. Pounds.	Weight of Comb. Pounds.	
	Night.	Day.				
Feb. 13	19.7	18.5	2500	397	2103	
" 13	13.38	29.3	700	...	..	
" 15	34.7	31.3	2627	457	2870	
" 16	31.9	32.9	2200	306	1894	
" 17	28.8	39.5	2000	336	1694	
" 18	41 65	35.9	2000	255	1745	
" 19	31.	28.6	2200	346	1850	
" 20	24.1	26.1	2000	300	1700	
" 21	31.9	38.4	600	...	..	Banked Fires 10 A. M.
" 22	24.7	33.4	1000	...	..	February 22.
" 23	32.6	34.	2400	...	..	
" 24	27.6	26.1	2100	484	..	
" 25	28.4	32.	2108	307	1801	
" 26	21.9	16.75	2100	303	2097	
" 27	11.72	15.85	2500	369	2191	
" 28	15.22	17.71	800	...	..	
March 1	10.4	17.22	3000	411	3389	
" 2	32.4	30.	2000	...	..	Shut down West Boiler
" 3	31.6	45.7	1417	...	..	at 9 A. M., March 3.
" 4	29.9	27.5	[illegible]400	...	..	
" 5	27.9	35.6	2000	...	..	Steam on operating shed
" 6	42.5	29.1	1600	...	..	all day, March 5.

through two registers, each ten feet from the floor and to the back and side of the lecture desk. It can also be supplied with air through two side registers at the same height. The size of each supply register is 21 by 29 inches. The vent flues have registers on the front side, back of the lecturer's desk, near the floor line, each 24 by 24 inches, and in the back of the room, on line of floor of top seats, two registers,



ELEVATION THROUGH A-B

FIG. 26.

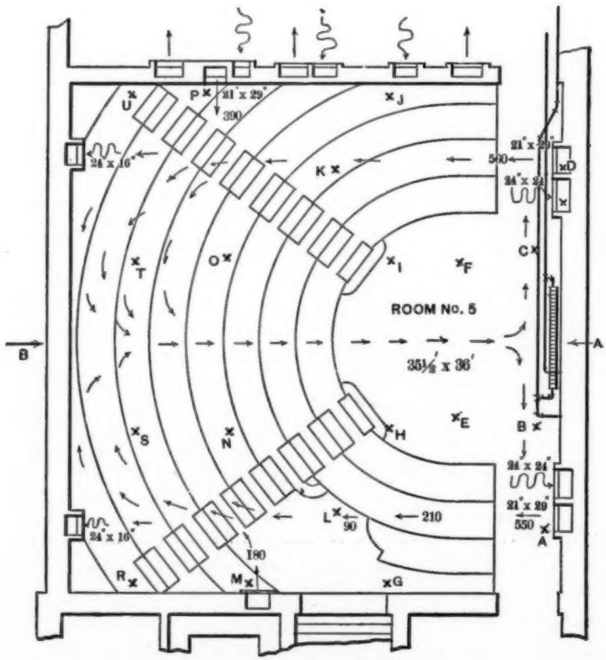
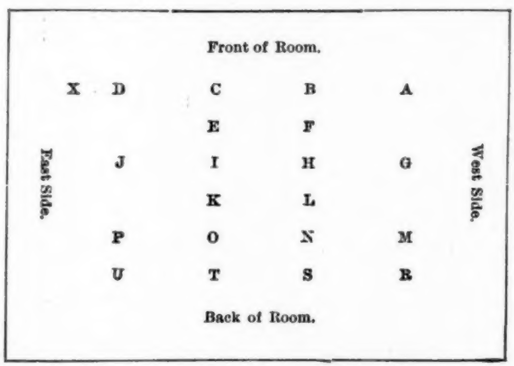


FIG. 27.—ANATOMICAL LECTURE ROOM.

each 24 by 16 inches. The positions of all these registers are shown clearly in Figs. 26 and 27, which give section and plan views of the lecture room. The approximate cubic contents, deducting 20 per cent for raised platform carrying the seats, is 20,400 cubic feet, the net area of heat registers, allowing 33 1-3 per cent for grills, is 12 square feet; hence the velocity of air entering at the registers, to completely change the air in five minutes, must be 340 feet per minute, or at rate of 5.6 feet per second. The area of vent register, making 20 per cent allowance for grills, is 11.6 square feet, and for same allowance of air will require a velocity of 352 feet per minute, or 5.8 feet per second. The room is designed for 135 students, and a supply of 30 cubic feet per minute for each occupant will demand 4,050 cubic feet per minute, a velocity in the entering register of 337 feet per minute, and a change in the air of the room in about five minutes of time.

VARIATION IN TEMPERATURE.—The temperature is regulated by



a thermostat on the side of the room near the position marked X. A careful study was made of the temperature in various portions of the room and also of the air currents which existed when the normal supply of air was introduced. For this purpose thermometers were hung at different elevations and in position as shown in plan by letters in the above diagram.

The thermometers at the higher position were denoted by letters with subscripts; that is, the thermometer over B in plan and near floor was marked B_2, that ten feet higher was marked B_1. When one thermometer only was used it was placed about two feet from floor and was denoted by a single letter without subscript. The positions of these various thermometers will be readily noted by re-

ferring to Figs. 26 and 27. Simultaneous temperature readings were made of these various thermometers as shown in Table VIII.

A study of these observations shows a great irregularity in the temperature in different portions of the room, although a trial showed that the thermostat would close the dampers with a variation of less than two degrees from the normal; on account, however, of imperfect closure of the damper on the hot air side at the time of the test, this could not prevent the room from overheating, especially in moderate weather, or in fact at any time, unless the tempering coils were regulated by hand. This, however, can in no way account for the

TABLE VIII.

Elevation.	March 6, 1897.					March 9, 1897.			
	No. of Thermometer.	Position.		*		3.15.	†3.30	4.38	4.50.
Near top	25	A	..	..	..	80.	79.	82.	82.
About 10 feet high	3	B_1	64.5	66.	67.	[illegible]	74.	75.	75.5
Near floor	2	B_2	63.5	64.5	65.5	68.5	69.5	71.5	71.5
Ten feet high	7	C_1	64.5	65.	67.	74.5	74.5	75.	75.
Near floor	13	C_2	67.	67.	65.	66.	67.5	69.5	69.5
	6	D	..	..	..	77.5	[illegible]	78.5	78.5
	23	E	..	..	..	73.	73.	74.5	74.5
	24	F	..	..	..	72.5	73.	73.5	73.5
	19	G	..	..	..	75.	75.	76.	76.
	11	H_1	65.	67.	67.	76.	75.5	76.	76.
	12	H_2	63.5	64.5	65.5	67.5	68.5	69.	69.5
	8	I_1	65.	66.5	67.	74.	74.	75.	70.5
	9	I_2	63.	65.	64.5	67.	68.	69.	69.5
	22	J	..	..	..	74.5	74.5	74.5	75.
	21	K	..	..	..	73.5	73.5	74.5	74.5
	20	L	..	..	..	75.5	75.5	75.5	75.5
	18	M	..	..	..	75.	75.	75.	75.
	4	N	65.	66.5	67.	76.	76.	76.	76.
	1	O	65.5	67.	67.5	75.5	75.5	75.5	76.
	14	P	..	..	..	79.	78.	79.	78.5
	17	R	..	..	..	74.5	74.5	74.5	74.5
	10	S	65.	67.	67.	76.5	76.5	77.	77.
	5	T	65.5	67.5	67.5	76.5	76.5	76.5	76.5
	15	U	66.	65.	67.	75.	75.	75.5	76.
	Thermostat...	....	66.	65.	67.	75.	75.	75.5	76.

* After opening doors and windows to outside air for ten minutes.
† Covered up the back exhaust flues after 3.30 P.M.

great difference of temperature in different portions of the room, since it is quite evident that even with perfect thermostatic action the same difference must probably exist, and the course of the irregularity must be sought elsewhere. At the time the test was made air was entering from the front register at the rate of about 550 feet per minute, from the side registers at the rate of 180 and 390 feet per minute, respectively, making the average velocity of entering air 420 feet per minute, indicating that a supply sufficient to change the entire air in the room in less than five minutes was entering. With this abundant supply of air the variation in temperature actu-

ally can be accounted for only on the supposition that the distribution of the air supply was extremely irregular and that certain portions of the room were occupied by eddies and were not supplied with fresh air. For instance, compare the temperature at B_2, a point near the floor and underneath the main supply of air from the front, at 3:15 P. M., March 9, with other temperatures; the temperature at B_2 being 68.5, while at C_2, a few feet away, it was 66 at the same time; and near the raised floor at T in the back part of the room it was 76.5 degrees. This condition would indicate that the air surrounding the feet of the lecturer at B_2 would be about ten degrees colder than that surrounding many people in the audience. This condition was somewhat improved by closing the discharge from the back vent flues. Such results are shown in the last two columns headed 4:38 and 4:50, from which it will be noticed that this had the effect of raising the temperature of the air at B_2 and C_2 or at the lowest portion of the floor, without any material increase in temperature at the higher portions.

AIR CURRENTS.—A study of the air currents in this room was made by burning gun powder in front of the radiators and noting the direction of the smoke, from which it was found that the general direction of the currents was toward the upper and back end of the room, where part of the air passed out through the back vent or eduction flues, but the greater portion was deflected toward the center, returning partly along the ceiling and partly lower down, to the front of the room, where it settled to the floor and again separated into two currents, a part going out at each of the front ventilating flues. This arrangement of the inlet and outlet flues is found to create noticeable drafts, which in some places could be measured with an anemometer, and at other places, where not so strong, by the deflection of strings suspended from the ceiling. The directions of the air currents as actually found are shown by arrows on the drawings. There is a decidedly unpleasant draft on the legs of the lecturer at B_2, and it is believed that if the back vent flues were closed and the front ones connected to the space beneath the seats, a better disposition of these currents would result, and it would be possible to eliminate the disagreeable conditions mentioned. In this case the openings to the ventilation flues would be placed in the risers back of the seats on the different levels.

A study of the figures on the diagram shows how soon the velocity of the entering air is reduced after passing into the room, due partly to overcoming the resistance, but mainly to expansion. Thus, air entering with a velocity of 550 feet per minute moves at a rate of 210 feet per minute after traversing a distance of ten feet, and with a

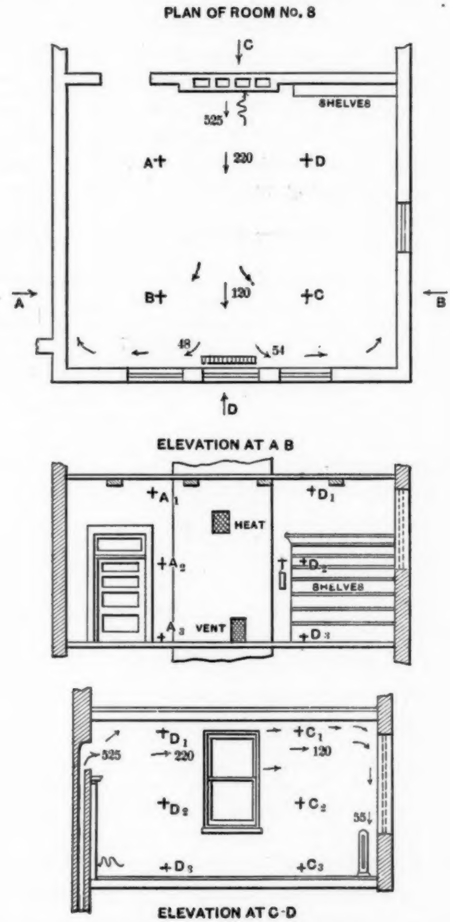
velocity of 90 feet per minute in a further distance of ten feet; from this point its velocity was too slow for accurate measurement, although, as pointed out, the principal motion is evidently confined to fixed courses, and certain portions of the room are occupied by still air unaffected by the motion of that passing in and out. It is believed, however, that a better disposition could be made by exhausting the air in risers of the platforms and bringing the entire supply in from two points.

DISTRIBUTION OF AIR CURRENTS AND TEMPERATURE IN ROOM No. 8.—This room is on the second floor; is 20½ by 24 by 12 feet and contains 5,904 cubic feet of space. It is supplied through a register, 12 by 20 inches, situated 9½ feet from the floor and in the center of one side. The air is removed through a vent register, 10 by 20 inches, situated near the floor line and on the same side as the heat register. (See floor plan, page 6.) A plan and two elevations of the room are shown in Fig. 28. The temperature was determined by thermometers located in positions denoted by letters on the drawings and arranged so that simultaneous temperatures could be read in all portions of the room.

VARIATION IN TEMPERATURE.—This experiment was undertaken to find the maximum variation in temperature, also to test the quickness of operation of the thermostat and ascertain how reliable it might prove in maintaining a uniform temperature of the room. The thermostat was located between the chimney and a book case (see Fig. 28) and was not favorably situated with reference to any possible air currents; it was also enclosed with an ornamental casing which still further protected it from currents of wind, and tests showed it to lag behind the average of that in the room from one to one and one-half degrees; it was also found that the thermostat would act with a variation of one degree of temperature with the casing removed and with a variation of three degrees with the casing in place. The hot air damper for this room was arranged so that it would close tightly; all heat was admitted through a brick flue about 27 feet in length and 12 by 12 inches in cross section.

The results of tests for variation in temperature are shown in Fig. 29. In this figure horizontal distance corresponds to time, vertical distance to temperature as observed in different parts of the room. When the experiment was begun, and from 2:50 to 3:30, the temperature in all parts of the room was nearly uniform, the extreme variation being within the limits of one degree and from 72 to 73 degrees. This condition, contrary to that in room 5, indicates an excellent distribution of air and is as nearly perfect as could be desired. To lower the temperature of the room the windows were thrown

wide open at 3:30 and the temperature of the room rapidly fell in different places to from 40 to 50 degrees at 3:35, when the windows were closed. The thermostat acted almost instantly on opening the



DIRECTION OF AIR CURRENTS SHOWN BY ARROWS, VELOCITY BY NUMBERS.
T POSITION OF THERMOSTAT.

FIG. 28.—PLAN AND ELEVATION, ROOM NO. 8.

windows and opened the damper for admission of warm air. The temperature of entering air is shown by line marked 2 on diagram. It will be noticed that this air gradually increased in temperature

from 73 degrees at 3:30 to 97 degrees at 4:20, at which time the thermostat closed the hot air damper and admitted tempered air; the until at 4:45 it was at the same temperature as at the beginning. It should be particularly noticed that although the damper opens fully or is closed tightly, so far as the warm air is concerned, yet it took a period of 50 minutes to reach its maximum temperature and 25 minutes to fall back to its normal temperature. This, of course, was due to the fact that the walls of the flue were heated, absorbing heat when the temperature increased and giving out heat during the process of cooling, thus ensuring a slow and gradual change in temperature of the entering air despite the fact that the damper was

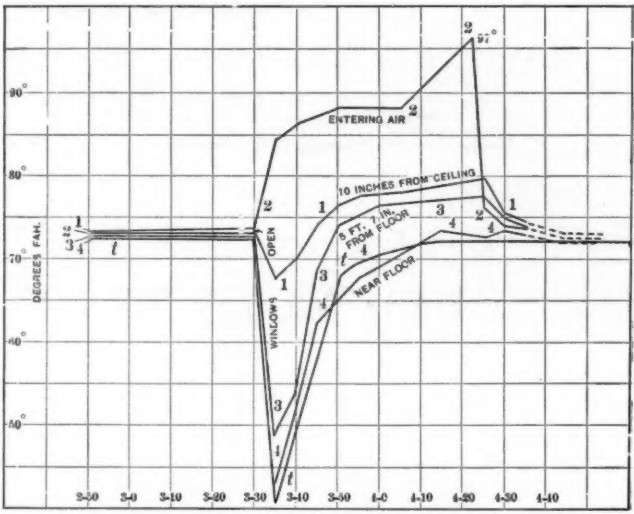


FIG. 29.—AVERAGE VARIATION IN TEMPERATURE, ROOM NO. 8, MARCH 13, 1897. OUTSIDE TEMPERATURE 8°. WINDOWS OPENED 3:30 TO 3:35. THERMOSTAT OPENED DAMPER 3:35.

suddenly opened and closed. The curve 1-1 denotes the change of temperature of a point ten inches from the ceiling, curve 3-3 that of a point five feet seven inches from the floor, curve 4-4 that of a point near the floor, t-t that as shown by the thermometer on the thermostat. It will be noticed that the temperature, as shown in curves 1-1, 2-2, and 4-4, all show, first, a rapid fall, when the window was opened, then a rise more or less rapid to a temperature several degrees higher than normal. The damper was closed when the thermometer at the thermostat was normal, which, as shown by the

line, lagged considerably behind the others. After the damper was closed the room soon reached its normal temperature.

Distribution of Air.—The distribution of air in room No. 8 is shown by the arrows on the diagram in Fig. 28. It is noted that the air, entering with a velocity of 525 feet per minute, reduces to 220 feet at a distance of five feet, to 120 at a distance of 15 feet, thence it strikes the back walls of the building, falls downward with a velocity of 55 feet when near the floor, thence flows to the vent flue with a very low velocity. The distribution seems to be all that can be desired.

Conclusions.—The investigation described will doubtless raise many questions, especially as to the reasons why other methods of introducing the air were not tried, and in reply it may be said that lack of time and money for such purposes prevented the introduction and trial of new devices. Few general conclusions can be drawn from a single test like the one described, but it would seem just and proper to call attention to certain conditions which point to a general application, as follows:

First, in the ventilation of similar buildings all air should be introduced sufficiently close to the ceiling to prevent the introduction of eddies above the incoming current, and when the rooms are not over 12 or 13 feet in height this practice is accompanied with an excellent distribution of air.

Second, in case rooms are 20 or more feet in height the distribution is not improved by admitting air in places about ten feet from the floor, as is shown by the experiments in room No. 5.

Third, to secure equable distribution the writer believes that, in general, air should be introduced at a distance two or three feet from the ceiling and discharged in a direction toward a cold, outer wall, and the vent opening should be on the same side as that for fresh air, situated near the floor line, and, if possible, diagonally opposite the fresh air inlet. When rooms are not over 20 to 30 feet in plan dimensions single openings will suffice; when they are larger additional inlets and outlets should be made, say about one for 20 feet, but so far as possible the general propositions as stated should be applied. I doubt the propriety, in any case, of introducing air so as to form cross currents. In case the room is very large the problem of introducing the air to secure equable distribution is a difficult one and involves so many conditions that it cannot with propriety be discussed here.

Fourth, the thermostatic control is of great aid in maintaining a uniform temperature, and practically there is no objection, on the

score of injurious changes of temperature, to a damper which is rapidly opened or closed.

Fifth, the thermostat should not be located in a position where the air currents cannot freely move, since in heating with air currents, unless there is a perfect distribution of air, the temperature may vary greatly in different portions of the room.

DISCUSSION.

Mr. J. J. Blackmore: Several questions occur to me that I would like to ask. In the first place, I would like to ask when the test was made, the coal test, was the draft damper controlled automatically—in the boiler?

Prof. Carpenter: There was no damper regulator.

Mr. Blackmore: In testing such a fan a comparatively low rate of efficiency was given, and I wanted to ask what the one hundred units meant. Was it the actual power put into the fan, or the rated capacity?

Prof. Carpenter: The actual power put into the fan. The power was determined by taking indicated horse power, deducting from that the friction of the engine and the friction of the belts.

Mr. Blackmore: It would be interesting also to know how the actual friction on that fan compared with the rated capacity of the fan; in other words, how near a ratio did you get to the rated efficiency of the fan?

Prof. Carpenter: I think that is hardly a fair question. The fan was a good one, and if it had been run at its proper speed its efficiency would go as high probably as almost any fan made. I did not intend that this paper should in any way reflect on the fan or its construction. The low efficiency was simply due to the low speed of running, thus allowing a great deal of slip.

Mr. Blackmore: The question was not at all to criticize the fan, because I have not the remotest idea what the fan was; but the question was to see whether there was any definite relation between the actual power taken as a unit by Prof. Carpenter and the rated power of the fan.

Prof. Carpenter: That fan had a rated capacity at least six times as high as it was run at.

Mr. William Kent: I would like to ask Prof. Carpenter where the lost work in the fan went, whether in heating up the bearings or heating the air that passed through it.

Prof. Carpenter: It was in heating up the bearings by friction

and also in slip, principally in slip. It was run so slow that we were really doing little but frictional work, and moving the air in the case.

Mr. Kent: I consider the analysis of coal as rather remarkable. That buckwheat coal should show volatile matter 13.91 per cent. would indicate that that coal came from the western part of the anthracite fields. It is semi-bituminous almost, which would account for its very high heating value; an efficiency of 72.9 per cent. from a boiler running at less than one-third of its rated capacity is also remarkable, and a rate of combustion of 3.28 pounds of coal per square foot of grate surface per hour, which is about the lowest figure I have ever seen in any boiler test on record, is worthy of notice. It is usually considered that you cannot burn coal so slowly without burning it inefficiently.

Mr. W. F. Wolfe: Referring to Figure 26, I should like to have as a matter of information Professor Carpenter's ideas as to the results that would have been obtained if the ventilation had been taken in proper proportion through each of the risers, carried into the chamber beneath, and also ventilated from near the floor line under the last riser.

Again, referring to the question of the position of the inlet, or rather the height of the inlet, has that any particular bearing when warm air is being introduced? If it is introduced at a line above the head line its natural inclination necessarily must be upward.

Again, in a room of that height of ceiling, is not what Dr. Billings wrote some years ago true, that in figuring the ventilation we should calculate below the 12 foot line as to the circulation to get the quantity of the air; that above that point there are several countercurrents, and it is only when we get within the 12 foot line we begin to get the circulation.

Prof. Carpenter: The questions asked by Mr. Wolfe relate to conditions regarding which I have thought a good deal. I should say that in the case considered very much better results would be obtained if the vent registers were placed in the risers below and back of the seats and the air conveyed around to the vent flues. I think in that way we would get rid of the eddies and also of the peculiarly bad current which goes down into the amphitheatre and flows by the legs of the lecturer. The peculiar form of the amphitheatre is such that it tends to guide the current of air downward, concentrates it nearly in one spot; by taking out the air as described by Mr. Wolfe, I think better results would be obtained. At least I have recommended that that scheme be tried.

As to the height of the entrance register for best results, I have not sufficient data to answer the question intelligently. It is quite

true, in fact was true in this case, that all the measurements of importance are to be taken within 12 feet of the floor line, and if Mr. Wolfe will notice the peculiar shape of the floor he will find that such was the practice in the case described. I think no measurements were taken near the ceiling, and many were taken near the floor. It strikes me that in order to get a perfect distribution of air we must introduce the air in such a way as to get no eddies. The currents of air tend to form eddies with about the same facility as currents of water in a running stream. If we introduce the air in such a manner that we have a large body of still air above, and in such a manner that our current is split and one part goes up and one part down, I think we certainly will obtain an eddy. At just what height air could be introduced so as to give a uniform current without an eddy, that is a current which would extend from the front backward, and in such a manner as to bring the ventilation in the whole room in one equable distribution, is a question certainly that I have not the data to answer. We have many data relating to rooms 12 and 13 feet high, and we get excellent results in those cases by introducing air near the ceiling, but there have been in the ventilation of high rooms a good many cases like this in which the results have not been entirely happy.

Mr. Connolly: I would like to ask Prof. Carpenter a few questions for information only. I assume that the direct radiators were not controlled by the thermostatic valves?

Prof. Carpenter: That is correct.

Mr. J. A. Connolly: I would like to ask him, assuming that they were controlled by thermostatic valves, would there be any economy, in place of shutting them off at seven o'clock in the morning, to have them continue to drive the air in from the fans by using the tempering coil, and as much of the heater coil as would bring it in say at 68 or 70 degrees? Would there be any economy?

I notice the plan of room No. 8, Fig. 28, with the air entering on the inner wall at 525 feet per minute; one-quarter of the room at 220, and three-quarters at 120, and dividing off into two currents of 48 and 54 feet per minute at the outside wall. Now, wouldn't there be a better distribution if that direct radiator was turned on and the air was coming in say 70 degrees—wouldn't it be more economical and couldn't you get sufficient air for the apertures at say a temperature of 70 degrees?

Mr. Blackmore: Before Prof. Carpenter answers that, I would like to ask another question in the same line. In the first room that was tested, the amphitheatre, a much higher temperature was found at the upper part of the room. I do not think that

Prof. Carpenter explained that he tried the closing of those openings to see whether it made any difference by taking the exhaust air all from the lower openings down where the lecturer stood.

Second, I would like to know whether experiments were made by closing one, two, or more of the warm air ducts to see how the one or two acted, and whether that made any difference.

Another question: Prof. Carpenter said it was better to have the one inlet and outlet on the same side of the room, and one over the other as nearly as possible. Now, how would that work in a room, for instance, where it became necessary from some conditions in the building to take the air on the inside corner, this being the exposed side of the room where all the windows were—supposing it was necessary to take all the warm air in at this corner, would it be better practice to take the foul air out here in the far corner, but still on the same side of the room?

Prof. Carpenter: Mr. Chairman, the question Mr. Connolly has raised is one that I certainly cannot answer because it involves the consideration of a condition and a system of heating which is entirely different from the one tested. I might say, to make the matter clearer, that the direct system in this building was entirely separate from the indirect, and was closed off at the boiler, and during the time the forced draft system was tested, it was not in use at all. It is an interesting subject suggested by Mr. Connolly. It is a comparison of one heating system with another, and it would be very hard indeed to answer it without exhaustive tests.

As regards the best position of the entrance registers, I have no definite knowledge since our test was limited to the conditions as found. My idea, as stated, was that it would be better to take the air out, not directly beneath the entering register, but near the lower corner in the same side and diagonally opposite the entrance register. I think there are very good reasons for believing that best results are obtained from that arrangement, but there might be some conditions in which it would not be satisfactory.

There is one point that I would like to speak of, which I think is of interest in connection with the test. In making this test there was an opportunity for determining just how much heat was lost from the walls of the building. I was quite desirous of measuring that quantity, for the reason that there is pretty good ground for distrusting both the tables which are used by Mr. Wolff, and those I have given in my work on Heating and Ventilation, and which were obtained from Péclet's experiments. The experiments of Péclet were on a small scale. I cannot find the originals that Mr. Wolff quotes as authority. The tables

in both cases are very nearly alike, and hence are worthy of credence. Now, neglecting the very elaborate rule that Péclet gives of correcting for height of walls, which is senseless and not founded on experiment at all, the tables show that with an ordinary wall about 1½ feet thick we have a loss of one heat unit for every four square feet of the wall, also a heat unit, or a little over a heat unit, for one square foot of glass for each hour and each degree difference of temperature. I think the experiments show from nine-tenths to one and one-tenth heat units for various conditions. In this particular instance I knew the total amount of air escaping and its temperature, and hence could compute the heat units discharged. I knew from the test the amount supplied, and hence could compute that escaping through the walls and window, then I had an opportunity of checking the rule, as stated above. The rule checks, as you see, within two or three per cent.

From this we conclude that "*the building loss per hour in heat units is equal very closely to the product of the difference of temperature into the area of glass in square feet plus one-fourth the area of exposed wall.*" The check is within two or three per cent, which would seem to indicate that the early experiments quoted were pretty fairly accurate.

Mr. S. A. Jellett: While we are discussing this paper of Prof. Carpenter's, which gives the results of one particular system in a particular building, I take it that the discussion of the subject of the general distribution of air in buildings similar to this is in order. It is the sum of the experience of the different members that we want to get out. I completed some time since a building which is used as an amphitheatre for a hospital. It is modeled on the system of tiers of seats with the exception that it is a complete circle, or rather an oval room, seating some six hundred men. The system I adopted in this building is totally different from the one described here by Prof. Carpenter. It could not be more opposite. The seats are a succession of circus tiers built of steel, the lower walls being all lined with marble, the upper walls of cement and finished with a glaze for sanitary reasons. The structural work of the seats is all of iron. The only wood entering into that room is the actual seat itself, held in place by the iron clamps. It is the largest clinical amphitheatre in this country, I believe, if not in the world. In this large room it is necessary to control the volumes of air entering, and its temperature, and also the outgoing air. After the main duct discharges from the fan in the basement and enters the structural work beneath the tier of seats, we have no means of controlling it, because the space under the tier of seats is used for

rooms for other purposes. The entire floor of the room is of sheet steel, and then is painted with a hard, glazed paint, which can be washed and disinfected. In addition to this, around the entire upper circle, there is a large perforated pipe, and after the operations, the disinfecting liquid is pumped through this pipe, and washes the whole floor, and the pit is connected to drains, its floor being of marble Now, we must be able to control the temperature in this room so that we could suddenly increase the temperature in case a patient was losing blood and needed greater warmth; so that the problem was very difficult. The air is brought into that room at 135 different points, so that the distribution is complete. The distribution is under the seats through cast iron necks built into the structural work, and the air is thrown forward and down and sidewise from each of those necks, so that while there are 135 goose necks, there are three times that number of discharges, as each goose neck divides into three branches. The next point was the keeping down of the velocity. It was fixed that it at no time should exceed 300 feet per minute under the maximum conditions of seating. The room gets a volume of air, from actual tests of some 24,000 cubic feet per minute, and I have never yet heard a complaint of a draft, yet the entire outtake is from the ceiling. The pit itself has two very large special registers on each side of the operating table into which there is a very large volume of air brought when it is necessary to increase the temperature in the space surrounding the operation itself. There is one thermostat only in the room, and that is located directly back of the operating table. It is arranged so it can be adjusted quickly. This thermostat operates a damper in the basement six feet wide by two and a half feet the other way. This damper is counterweighted and is operated by compressed air, the air compressor being controlled by the thermostat in the room. Now, we have a heater in front of the fan and a tempering coil on the inlet side of the fan, with a bypass pipe passing under the main heater. The mixing damper is at the junction of the two main pipes in the basement. It mixes at the connection of the hot air duct with the tempered air bypass rising from under the main heater. Beyond this point we have no control of the temperature, because the ramification of ducts, following the construction of the building, makes it impossible to get at them. Each of the main branches, however, in the basement, as it enters the steel shell, has wedge dampers; that is, wedge dampers are arranged with locks and adjusters, and when the system was completed a series of readings were taken with all dampers open, and we found that certain branches that had less friction got a greater supply

of air. We then took the sum of those readings and averaged them carefully, adjusted the wedge dampers, reducing the area of branches that delivered too much air so as to direct more air into the branches that had insufficient air. There was a second series of tests and a third and fourth series made to get the best results. The final test showed that the highest velocity of any discharge was 316 feet per minute, and none were under 280 feet. In the ceiling there are 12 registers, which have no valves. Each is 24 inches in diameter. They connect to a series of ducts leading to a central aspirating chamber in which there is a large steam coil supplied by lines of pipe controlled in the basement. In addition to the heat coming with the air into the room, we have steam pipes along the ribs of a skylight some 20 feet wide, and a total of 24 feet long, rising against the north wall and then turning across the ceiling of the room; it is in such a position that the sun can never strike it. To prevent the condensation against the glass we have placed on the ribs dividing the skylight a steam pipe bent to the same curve as the skylight connected to supply and return pipes into the basement, where they are all controlled. This is done to prevent any sweating on the glass and consequent drippage. I found some time ago in another hospital that this dripping of water was a very dangerous thing. In one case where a doctor was operating on a patient the drip of condensation hit him in the neck. He had the operating knife in his hand at the time. He sent for me and said something would have to be done to prevent it, as a drop of hot water like that might cost a man's life. He said that anything coming so suddenly might cause the knife to slip. In the skylight coils described we used bent pipes without joints from the manifold above to where beyond the turn of the skylight where the pipes are in a vertical position. Under the manifold, running horizontally, there are copper gutters so that any drip can be taken care of. The heat from these coils prevents the sweating and dripping from the glass itself. This same arrangement is carried out in four private operating rooms used for special operations. The system used in this building is a novel one in a great many ways. The test shows an equal flow of air and a remarkably even temperature. The last test taken I made myself about six weeks ago during an operation. I wanted to see the effect on the temperature of the radiation of the bodies of the students. I placed a thermometer within 12 inches of the floor directly back of the operating table, and another within two feet of the ceiling. The ceiling was 50 feet high. The room was empty and the record taken of the thermometers. Some 300 students were then admitted and the temperatures were taken from that time on every ten min-

utes from the two thermometers which had been checked and compared before. The total rise during the operation, which lasted one hour and twenty minutes, was two degrees, and the total variation between the ceiling and the floor was three-fourths of one degree. It was the closest regulation of heat I had ever seen in any such height of ceiling, and I explain it by the distribution of air; the 135 points of intake multiplied each into three subdivisions spreading the air over the entire pit, and then a direct rise to a flat ceiling from which there was a direct exhaust. This system has been in use for some time now, and the doctors tell me that at no time have they felt a draft during operations or in any part of the room. They also have been watching the thermometers, and they tell me that there is apparently no variation that they can detect on their thermometers, which are the ordinary hospital thermometers. The private operating rooms are handled by an entirely different system. There are two flues side by side. One flue discharges hot air at a temperature of 160 to 165, the other cooler air at a temperature between 80 and 90 degrees. Both flues are of the same area. In each there is a damper with a lever at the top, the damper being made on a curve. The doctor wished to be able to control the temperature in each room irrespective of the temperature in any other. Therefore, we could not put thermostatic control on them. The room is ordinarily kept, we will say, at 70 degrees, but if a patient requires more heat, the doctor or attendant moves the lever to the right, the tempered air is shut off and the full volume is brought in at 160, driving the room to 80 or 90 degrees if necessary. These operating rooms are lighted by skylights that have the same rib coils that I have already described. The doctors can control the temperature at will in these rooms up to 90 degrees, which is as much as they ever need. They can also, taking the average winter conditions, lower the temperature below 70 to 65 degrees. The air coming into the room is brought from above the roof of the building on the north side, and is washed through a spray of water, first, in the shaft itself. It is then drawn through the air room in the basement and then passed through a dust screen, so that any excess of moisture or any dust can be deposited on this screen, which is made of very fine copper gauze. There is also a spray of water on this screen for washing, and this screening and washing is all done before any air enters the tempering coils. This system, as I have said, is just as opposite to the system described by Prof. Carpenter as two systems could well be, and yet the results are very satisfactory. The same application to another building may give entirely different results and be very unsatisfactory. The problem to be considered by the heating and

ventilating engineer is to design a system that will best meet the needs of each particular building, considering all its conditions. If all our members will describe their experience with work of this kind, it will contribute to the general information of all our members and will serve as a guide in future work.

Mr. Wolfe: I think that I may be able to give Mr. Connolly a little information regarding what would happen if the steam on the direct radiator, as shown in Fig. 28—if the steam is turned on when the ventilating system is in operation. I have seen that arrangement tried under a smoke test where we might watch the currents. Of course, we all understand that we depend largely, if not altogether, upon gravity for the circulation of air through a room; that is, that the warm air goes to the ceiling, and finding a colder surface, condenses and falls, and so makes its circuit towards the outlet whether moved by gravity or power. Now, under those conditions, with the direct radiator in action, warm air rises, which meets the falling air from the ceiling and makes an eddy. I think the difference in the temperature as noted on the drawings which were taken in the neighborhood of five or six feet from the floor, not at the ceiling, simply illustrates that in falling the air has lowered in temperature. If the radiator had been warm it would have reheated that air again, and sent it back, and there would have been an up and down current. The direct action of the air from the inlet would be in the shape of a fan, and then, under the law of gravity, it would naturally spread itself evenly across the ceiling and drop. I have seen similar experiments tried several times, and it is simply a meeting of one current with the other, up and down.

Mr. Northrop: There are one or two features of this interesting problem on which I would like to draw a little information. It strikes me as exceedingly singular that there should be a reverse current of air in this room. I do not mean that it is singular as to this room, but it is singular as to rooms in general, that there should be a reverse current of air passing immediately under the wall in the opposite direction to the incoming current of air from the warm air radiator. If I remember rightly, the warm air is introduced at about 100 degrees, from which one would suppose that before the air would reach the middle of the room it would make a curve and ascend to the ceiling. It therefore prompts this question: Is there some peculiar construction of the ceiling there that will account for such action? What is the construction of the ceiling of the building?

Prof. Carpenter: Nothing peculiar. It strikes me that under the conditions for introducing the air the natural way for the currents to move is that found by measurement and test. The air entering is

rather warmer than the air in the room. It enters, we will say, about midway up the room at four points, goes over and strikes the opposite sides, forming by resistance eddies which cause the back currents.

Mr Northrop: A little further, if you please—the difference between the incoming column of air and the body of the air in the room is considerable.

Prof. Carpenter: Not very much, about 10 or 15 degrees.

Mr. Northrop: Well, I supposed that there was more than that, the body of air in the room being about 70 and the incoming air somewhere from 80 to 100 perhaps. The powerful tendency of air at a higher temperature to rise through a body of air at a lower temperature—from that it seems to me that there should be a curved line there instead of a straight line across. Aside from that, there is another thing by which we are sometimes misled, if I may call attention to it. It is a fact that smoke does not accurately follow the currents of air, for the reason that smoke and air are of different degrees of density, and if you liberate a body of smoke upon a column of ascending air it will more truly trace the column of ascending air than the column of horizontally moving air, because the action of gravity is different upon it. In the one instance it is in a vertical line with the other, and in the other instance it is drawing down at right angles to the column of incoming air. Therefore, when you try to trace the motion of the current of air coming in upon a line horizontally, or approaching the horizontal, there you will unavoidably be led into error. Your smoke will not exactly follow the current of air. It has a tendency to depart from it in proportion as its specfic gravity is at variance with the specific gravity of the incoming column. That is not true with the ascending column because they are then upon the same vertical line.

Prof. Carpenter: So far as the direction of the lines of motion is concerned, there is probably no doubt that the current should be shown by curved lines. The direction of the ceiling currents is not shown on the drawings. The mere fact that there was a back current on the ceiling is all that is indicated here. The straight line which is shown here by the arrows indicates the general direction of the main current down on the floor in the lower Figure 27. The elevation merely shows a back current along the ceiling. In regard to the temperature of the entering air, I would say that the log shows that the temperatures vary from 79 to 82 degrees, being only a few degrees higher than the temperature in the room. Such a large volume of air was introduced that the temperature of the air was very nearly uniform.

The smoke particles would doubtless move as indicated, and it is probable there might be in some cases a little variation from the air current and the smoke. That variation would seldom be so much but that the general trend of the current would be shown. In connection with the smoke test anemometers were used and also a sort of anemometer in the shape of a very light threads hanging in this room; as they swung forward we could estimate the movement of the current. There is no question whatever as to the general direction of the currents. In fact I am very certain that they took the direction shown here, but it is to be understood that the arrows merely indicate the general direction. They do not indicate the exact course and path of the air.

Mr. Blackmore: Mr. Northrop introduces a very interesting question and one that I really am engaged in trying to determine now. I am not quite clear yet to what extent the smoke stays in the room, so that the air can pass through it. I have noticed repeatedly in smoke tests that the pump was nominally changing the air as much as ten times an hour, and you could not get the smoke out in 20 minutes, and sometimes not in half an hour, and yet my anemometer showed me that the air was actually changed nine or ten times an hour. I confess I have not been able so far to see where the difference is. I am experimenting with peppermint, to see how quickly you get rid of the scent in the same room. So far, while I have not accurate data, the experiments go to show that the peppermint will disappear very much quicker than the smoke. I believe that smoke test will show the directions of the currents, but it will not tell how often you are changing the air in the room.

Mr. Rockwood: Is the phenomenon accounted for by the fact tnat the air is not changed once in ten minutes; you simply introduce that quantity of air once in ten minutes, and you take it out once in ten minutes. The air that is in the room remains in the room permanently. I think that very frequently happens.

Mr. Blackmore: That is the point I am trying to determine. Peppermint, as you know, is a very permeating perfume, if you will allow the expression, and it will linger in a room as long as there is no current to take it off. Now, we see the smoke lingering there, and the natural assumption is that the current does not move where that smoke is. Now, if the odor of the peppermint disappears say in 15 minutes, it would indicate that the air in every part of the room had changed. As far as my experiments have gone now (although, as I say, I have not made enough to come to any definite conclusion) my conclusions are that the peppermint disappears a great deal quicker than the smoke.

Mr. Wolfe: I think regarding that matter that we all thoroughly understand that ventilation is nothing more or less than dilution. Regarding the smoke test, that was illustrated by a description by Dr. Billings a number of years ago. He states, I think, that if you take a glass and discolor it with milk, we will say, to a very appreciable extent, making it white, and then take a pitcher that will hold five times the amount of water that the glass will hold, and pour it through slowly so that it will gradually mix and overflow—after you have filled that glass four or five times there still will be a tinge of white. Regarding the smoke test, I quite agree with you that it takes from 30 to 45 minutes to elimiate all trace of the smoke. Regarding the peppermint, I do not think that the peppermint is lost in 15 minutes. We all know that we can become accustomed to an odor and then we do not notice it. If in trying the peppermint test you will go outside for a few minutes and come back, I am not at all certain but that you would again smell peppermint. It may be that it is the nose and not the peppermint that is at fault there. I think all that is claimed in ventilation is that an amount of air shall be introduced that shall be sufficient to so dilute the vitiated air as to keep it practically pure. In testing with smoke, of course the smoke comes in in a dense mass and the room is filled. Every instant it becomes less and less, and thinner and thinner, and (under ordinary conditions of ventilation the air in a school room, we will say, is changed once in about eight minutes) it takes pretty nearly 40 minutes to get it out. But your air is getting better and better all the time, because you are diluting with fresh air.

Prof. Carpenter: I think the question of the application of the smoke test as raised here is very different indeed from that made in the paper. As described by the last two speakers, the smoke test is used as a means of measuring the velocity of the air. In the paper the smoke test described was merely the means of noting the direction of the currents. Now, I think that measuring the velocity of the air by a column of smoke will certainly be very inaccurate, because the smoke is made up of solid particles, which are very many times heavier than the air, and it is only a question of a very short time when those particles will begin to lag behind the air currents, and move very much slower. I do not think you could use the smoke test for anything except the most approximate measurements of the velocity of air. I do not know how it would be with peppermint; but I presume would depend on the sense of smell. It seems to me that Mr. Wolfe has stated the problem of ventilation so far as the velocity of air is concerned; it is the introduction of a certain amount of air, and we must determine the velocity by the measurement of the

amount that comes in. I do not think it is possible to obtain a sufficiently accurate measurement of velocities by a floating substance of any kind. I think even the scent, peppermint, will lag behind.

Mr. Northrop: I was speaking of the effect of a current of air traveling transversely through a column of smoke discharging into it; that is a column of air traveling horizontally or on a line approaching the horizontal, and a column of smoke is discharged into it, so as to indicate the direction of the column of air. The point that I make is that the particles of smoke are heavier, and that the column of air heated to a certain temperature, maintains a uniform temperature as it travels through this room. As the smoke follows it, it gradually drops behind and drops down and refuses to indicate the curves and the high velocity in those curves. It refuses to indicate what is actually transpiring in the room, as I maintain—an ascending column of air, and especially on the top of the stratum of air traveling across the room.

Prof. Carpenter: I see that I do not convey a clear idea of our smoke test to the minds of our members. It seems to me that for indicating a rapid current the smoke is quite accurate in the case in question. The fact that the smoke did show a divided current, one going up along the ceiling and one on the floor—the smoke being naturally heavier than the air tends to fall downward. In spite of that we get a return current, visible along the ceiling. This indicates that there must have been a very strong velocity there; otherwise the smoke would not have moved upward. The ceiling current must have been very strong in order to have been shown by a heavier material than the air. I hope I make the point clear. I do not see how this has anything to do with the general question raised regarding the measurement of velocity by the smoke test. But I do think with Mr. Northrop, that the current that is shown by the smoke is a very strong one. That is the point I make; the smoke will not show a weak current; it will lag behind and fall beneath. It is like throwing a big chunk of mud into a stream. The water will dissolve the mud and carry it along. The mud may finally sink down to the bottom and fall behind, but it will show the existence of a current so long as it stays in the water. Furthermore, the smoke is likely to show with more intensity lower currents than upper ones, because of the tendency of the particles to settle. I cannot see that there has been any bad logic in the reasoning.

Mr. Barron: I will try to confine myself to the paper. One thing that struck me was the consumption of coal. Prof. Carpenter does not do as we do where our customers are burning too much coal.

We calculate as nearly as we can what the plants ought to burn, and we tell them so, and they show the letter to the engineer, and the result is that we often find is that the engineer gets the coal consumption down to what we say is all right. A great deal more depends on the man who has control of the management than on the engineer who designs or constructs the plant. I want to take up this subject of the relative cost of electric power and heating power. I am surprised that it comes from the engineer who made the Milwaukee engine test. He assumes that what does exist to-day is going to exist, and he gives all the advantage to the steam power, and all the disadvantage to the electric power. Under the conditions that exist with marine engine work, Prof. Carpenter would readily admit that if we could get the same economy with an electric plant as in a marine plant, or such as he got in the Milwaukee engine test, the engineer could furnish electric power cheap enough to sell it in competition and sell it cheaper, and with his conclusion based on such favorable data to electrical power, then these other conditions would almost be reversed, but in any case electric power would only be equal in cost to the steam power, and its convenience and adaptability would give it the preference. I know in many cases, where you are consulted about the cost of installing electric plants, in figuring up the cost you find you can buy power from the larger plants cheaper than you can put in a plant and pay interest on it, that is, a small plant. This will solve a great many problems; for instance, the problem of electric heating. If we can take the exhaust steam and make a better use of it than heating the feed water, we certainly will use it in that way, and we will produce electric power so cheap that we will heat by electricity almost altogether, and when I state to-day that electric heating is coming, I feel it and know it, I feel that it is almost here. We have had here to-day some of the most prominent steam engineers in the world, and they have certainly considered this subject. It is an old problem. But I simply wanted to draw them out and get their opinions, and I am sure if they expressed their opinions they will admit that they believe that electric power will soon be cheaper than any other form.

Mr. Reginald Pelham Bolton: I think the enthusiasm of the last speaker needs a little condensing water on it. I am entirely in accord with Prof. Carpenter's conclusions on this matter, and I must say that when he put the figures for electric currents in a small place out of the neighborhood or any large city at 10 cents a kilowatt hour he is doing a very reasonable thing. The cost of electric power in this city at the present time, retailed in

such small quantities as this, is 7 or 7½ cents per kilowatt hour; and that is making it in the largest quantity in which it is turned out in any part of this country for illuminating and motive power purposes, the cost may be reduced to as low as five cents per kilowatt hour in the near future. But the best we can do in our individual plants is not better than about 2½ or 3 cents per kilowatt hour. That economy is reached by the use of the exhaust steam in the heater as an economic addition to our plant. In heating our buildings we take the exhaust of our engines and we make economical use of the whole of the heat between that and what we return to our feed heater or our drip pumps as the case may be. Therefore, I think that any idea of competing with electric power to drive such apparatus as described in this paper is entirely in the air at the present time.

I would like to make one other reference to the paper itself. In reference to that very interesting room and the discussion which has taken place in respect to its method of heating and ventilation, it seems to me that the initial difficulty is the velocity of the air in that case. It is perfectly manifest that the introduction of the air is in the wrong place in view of the peculiar shape of the lower portion of the room, but that it is aggravated by the speed at which the air is introduced.

I should like to add my thanks to those of others to Prof. Carpenter for an exceedingly valuable paper to all heating engineers.

Prof. Carpenter: I have not been talking about electric power. I have not said a word about it. I merely mentioned that it would cost us out in Ithaca a certain amount of coal for direct engine powers, and if we put in electric power it would cost us another amount. I did not say that electric power was under other circumstances poorer or better. In fact, I might say that so far as outside work is concerned, that work which I do outside the university, it has consisted largely in putting up electric power plants. If I am interested in any one thing in the world it is the development of electric power, and it is pretty certain that I would not say anything to discourage the use of electricity if it could possibly be helped. In this particular case the figures were just as they are represented. It is certainly going outside of the scope of the paper to raise the question as to the future use of electricity in heating.

Mr. Rockwood: Do you use any lights in that building at night?

Prof. Carpenter: Yes, and we get those from the same source.

Mr. Rockwood: From the city?

Prof. Carpenter: Yes. I might say we have a university plant, but it is not large enough to serve this building, in addition to what

was already carried, so they are getting the supply from the city plant.

Mr. Rockwood: How large a lighting plant would it take to light that building?

Prof. Carpenter: The building is wired for 2,000 lights.

Mr. Rockwood: They are not used for recitation purposes are they?

Prof. Carpenter: No; only a very few are used at night.

Mr. Rockwood: What I was coming at was that possibly by the use of storage batteries the cost of lighting the building might be reduced a good deal by running the dynamo, which would charge the battery, from the fan engine.

Prof. Carpenter: I might speak of a condition which perhaps is not realized here, but which is true in regard to nearly all college buildings. The night use is irregular and it would be very difficult to provide for it in any general sort of a way. That is, we might go to more expense for a plant than would be warranted by its use, and that probably holds true here. Of course, it is noted that the entire heating is done by the exhaust steam in the cold weather. In other words the efficiency then is 100 per cent, so far as our coal bill is concerned. It is only in the warm weather that the problem comes up. In the warm weather we have another thing that counteracts the importance so far as the lighting is concerned. The building is used very little after half past seven and hence very few lights are used. So those conditions would prevent the installation of a large plant.

Mr. Rockwood: While on that topic, although it is not applicable to Prof. Carpenter's building, it nevertheless is a good idea to merge the lighting plant into the heating plant in such a building by charging the battery during the day with a dynamo run from the fan engine; because all the steam that would go into the heater would be live steam and we might just as well pass it through a reducing valve (which this engine evidently is), and get our power during the day from that source.

Mr. Bolton: The trouble with those people who are struck with the storage battery is that they lose sight of the cost of maintenance of the battery and the extra attendance required in that case, and it appears to me very often a very doubtful problem indeed to introduce any relation between the heating problem and the lighting problem. Lighting is a very variable quantity. Heating is a fixed quantity which exists through certain months of the year, only, as a source of economy, as lighting is a thing that may be demanded all the year round and may during other portions of the year be a source of loss.

Mr. Rockwood: Since we have touched on the storage battery, I would say that I have been operating storage batteries for the last two years. A storage battery does not require any extra attention beyond the attention you would give to very ordinary apparatus. Furthermore, as this battery is used for lighting the watchman's circuit, it figures out that the cost of lighting the watchman's circuit by means of the battery is less, all things considered—depreciation of battery, expense of maintenance, etc.—than it would be if we paid the regular meter rates for the city supply. Furthermore, we have light in the building all the time, night and day, whenever anybody wants it, just as though we used gas.

XLII.

PROPORTIONING OF CIRCULATING PIPES FOR STEAM AND HOT WATER HEATING SYSTEMS.

BY J. J. BLACKMORE, NEW YORK.

(Member of the Society.)

The art of supplying artificial heat for buildings by means of hot water and steam has made rapid progress during the past 30 years, and yet, notwithstanding this undoubted progress, there still remains a good deal of doubt as to the proper method of adjusting the size of flow and return pipes for heating plants of different sizes. Several rules have been formulated to meet this want by engineers, but they all differ materially as to the size needed.

Mr. George H. Babcock, in a paper read at the meeting of the American Society of Mechanical Engineers, during the year 1885, submitted the rule that: "The diameter of the main steam supply pipe should be equal to one-tenth of the square root of the total amount of radiation in a system." Mr. W. J. Baldwin practically uses the same rule in his book on "Steam Heating," though he does not define it in exactly the same way. Mr. A. R. Wolff, in the addendum of a little book by Mr. W. R. Briggs, Van Nostrand's Science Series, No. 68, offers a rule, that: "The area of the main steam pipe should be equal to 0.375 square inches for each 100 square feet of heating surface, and when live steam is fed to the system a ratio of .19 square inches is sufficient." Prof. R. C. Carpenter, of Cornell University, in his recent work on "Heating and Ventilating Buildings," gives different ratios, from 0.90 square inches down to 0.225 square inches, based upon the velocity of steam flowing through the pipes at different pressures.

Let us first consider the application of the rule of Mr. Babcock and Mr. Baldwin to four different size plants, one of 400 feet, one of 1,000 feet, one of 1,600 feet, and one of 15,000 feet. For the 400 feet we have a 2-inch pipe, for the 1,000 feet, a fraction over a 3-inch pipe, for the 1,600 feet a 4-inch pipe, and for the 15,000 feet a pipe a little over 12 inches in diameter.

Now let us take that of Mr. Wolf, of 0.375 square inches of area to each 100 feet of radiation. By this rule we would have a $1\frac{1}{2}$-inch

pipe for 400 feet, 2¼-inch pipe for 1,000 feet, 2¾-inch pipe for 1,600 feet, and for the 15,000 feet an 8½-inch pipe.

We will now consider the rule of Prof. Carpenter, of 0.90 square inches of area in the main for each 100 feet of surface; this gives a little better than a 2-inch pipe for 400 feet, a 3½-inch pipe for 1,000 feet, nearly a 4½-inch pipe for 1,600 feet, and a 13-inch pipe for the plant containing 15,000 feet.

Comparing the rule of the two gentlemen first named with the rule of Mr. Wolff we find a difference of nearly 100 per cent; comparing the same two with Prof. Carpenter we find a difference of over 12 per cent; comparing Prof. Carpenter with Mr. Wolff there is a difference of 130 per cent, certainly a very wide variation and very puzzling to the novice in the science of heating by steam and hot water.

Prof. Carpenter, in the work before referred to, is the only writer who mentions the fact that a different ratio is required for a small plant than for a larger one, and he says it .n these words (page 225): "Mr. A. R. Wolff gives the following rules for determining the cross sections of area of pipes;" then follows the quotation of Mr. Wolff's rule, upon which he comments; "By consulting the table it will be seen that the constant for area 0.375, found in column two, corresponds to a velocity in the steam mains of about 62 feet per second, and it is not well suited for use with low pressure steam, or when resistance to flow must be very small." Prof. Carpenter here admits that a ratio suitable for a large plant cannot safely be applied to a small one, but he leaves the impression on the mind that the difference is because a pressure of five pounds is carried on the large plant and only the pressure of the atmosphere is kept on the small one.

Mr. Wolff does not state that he carries a pressure when using the ratio of 0.375, but he says: "It will be ample to allow a constant of 0.375 of a square inch, plus, for each 100 feet of heating surface in coils and radiators, 0.375 when exhaust steam is used, and 0.19 of a square inch when live steam is used." This clearly shows that Mr. Wolff set the ratio for atmospheric pressure, or nearly so, as he gives the same for exhaust steam, and further, when he uses the ratio 0.19, he does so because, with live steam, a pressure is carried. This clearly shows that these engineers suggested and used these rules for atmospheric pressure. These gentlemen are all practical engineers and have done and are doing excellent work on the basis of these rules.

A close investigation of the basis for these rules prove them to be correct, provided we allow each one the premises upon which

he based his calculations. They all err in allowing it to be supposed that the ratio is a fixed quantity for all sizes when the length and pressure is equal. Errors have been made by following these rules without a proper appreciation of the conditions for which they were provided.

For some years the writer has believed that a simple rule could be adopted that would reconcile these differences and establish safe ratios for all sizes of plants. With this end in view various observations have been made on different plants from time to time, as the occasion presented itself, to verify the correctness of the rules here presented, and they seem to accord well with the experience of many successful engineers.

Pipes for Steam Heating.—Before we define the proposed rule let us make a calculation of what area is required for supplying 100 square feet of radiation, for this is the basis from which the rule is worked. Each square foot of radiation, when the steam in it is at 212 degrees, will lose about 255 units of heat per hour; hence, we have to furnish 25,500 units of heat to supply 100 square feet. As each pound of steam loses 966 units in condensing we would have to supply $\frac{25500}{966} = 26.4$ pounds of steam per hour. Each pound of steam at a temperature of 212 degrees occupies space equal to 26.4 cubic feet; then, $26.4 \times 26.4 = 697$ cubic feet of steam per hour, to be supplied to radiators containing 100 feet of surface through a pipe 100 feet long.

We can assume the steam as flowing at a velocity of 25 feet per second, which is about correct for steam at atmospheric pressure under these conditions; then 697 cubic feet per hour is equivalent to $\frac{697}{60} = 11.616$ per minute, or $\frac{11.616}{60} = 0.196$ cubic feet per second, which is about equal to the capacity of a $1\frac{1}{4}$-inch pipe. In passing steam at this velocity through 100 feet of pipe a considerable loss is occasioned by friction, which we will put at 25 per cent; there will also be a considerable loss by radiation or condensation of steam, which we will also assume is 25 per cent, and this will be the case even if the pipe is well covered. This would give us an area of 1.83, which is rather more than the capacity of a $1\frac{1}{2}$-inch pipe. This accords well with practical experience, for most engineers recommend never to use a horizontal main less than $1\frac{1}{2}$ inch, and for the conditions here given all the heating men with whom the writer has conferred would not risk less than a 2-inch pipe to heat 100 feet of radiation placed at an average of 100 feet from the boiler.

These results establish a sure basis for a calculation of what can

be done with a small pipe, and that the proper ratio of area of main for 100 feet of radiation is nearly two inches when calculating for 100 feet only. We will now consider a method of changing this ratio to suit any size pipe of larger diameter. It is well known that a large pipe will deliver much more of a given fluid in proportion to its area than will a small one, supposing that in each case the length and pressure are equal, and that this power increases with the diameter. This being a fact we have only to select some constant and divide the diameter by it to obtain the proper ratio for all sizes.

The writer finds that the ratio of the circumference of a pipe to its diameter, 3.141, is the most suitable, because the friction is due to contact with the inner surfaces of the pipe, and it decreases directly as the diameter increases. From this we get the rule that: The ratio of main pipe for each 100 feet of radiating surface is equal to the quotient obtained by dividing 3.141 by the diameter of the pipe, and may be expressed as follows: $R = \frac{3.141}{D}$ in which R is the ratio and D the diameter of pipe. Then, to ascertain how much radiation we may safely put on any size pipe, we have this expression: $R = \frac{a}{r} \times 100$, in which R is the amount of radiation, a the area of pipe and r the ratio as found in the former expression. By this rule the following ratios are given for the different size pipes, with the area and quantity of surface each size will supply:

Diameter of Pipe, Inches.	Ratio for each 100 Feet of Radiation.	Area of Pipe.	Quantity of Radiation it will Supply.
1¼	2.50	1.227	50
1½	2.10	1.767	84
2	1.57	3.141	200
2½	1.25	4.908	400
3	1.04	7.068	700
3½	.90	9.621	1062
4	.79	12.566	1590
4½	.70	15.904	2272
5	.61	19.635	3116
6	.52	28.274	5424
7	.45	38.484	8552
8	.40	50.265	12560
9	.35	63.617	18175
10	.31	78.54	25336
11	.285	95.03	33340
12	.26	113.09	46600
13	.24	132.73	55300
14	.22	153.93	70000
15	.21	176.71	84000

The size of return pipe cannot be fixed by any definite law of mathematics, for the reason that the return has to do more than carry back the water of condensation; it must be large enough to equalize the pressure in the system. This can only be determined

by practical experience, and it has been found to be from one-third to one-half the area of the feed pipes.

PIPES FOR HOT WATER HEATING.—In arranging circulating pipes for a hot water heating plant the conditions are somewhat different than they are for steam. The friction on the water passing through the pipes is much greater than in the case of steam, but as an offset to this the hot water is not affected so much by the loss of heat, hence, the results work out for nearly the same size as for steam, except that in the case of hot water the return pipes must be the same size as the feed, and it is to be understood that the sizes given for hot water include both feed and return.

As in the case of steam, we will take as a basis for our calculation 100 feet of radiation. We will assume that each foot of hot water radiation will lose 175 units of heat per hour when working at a temperature of 185 degrees; then, $175 \times 100 = 17{,}500$ units per hour, with a difference of ten degrees between the flow and return; this would require 1,750 pounds of water to supply the lost heat. At 8.25 pounds of water to the gallon this represents 212 gallons per hour, requiring, for a 1¼-inch pipe, a velocity of about 55 feet per minute. We will now assume that the flow and return pipes are 100 feet in length and that there are 12 right angle elbows and a valve on the run.

By Weisbach's formula $(.0144 + \frac{.01746}{\sqrt{V}}) \times \frac{l}{d} \times \frac{V^2}{5.4} =$ head or column of water required to overcome friction in a straight pipe, V being the velocity in feet per second, l the length, and d the diameter of pipe; this is equal to .953 feet head. Now we have 12 quarter-turn elbows and a radiator valve, which is equal to two ells, or 14 elbows in all. Each elbow is equal to a loss of head of $\frac{V^2}{2.9} = .012$, which, multiplied by 14, equals .168 head lost by friction due to the elbows. With .953 feet lost by friction in the pipe and .168 by elbows the total loss is 1.121 feet. To produce the velocity necessary to supply the quantity of heat required with a 1¼-inch pipe we would need a head of nine feet, and, adding for the loss by friction, ten feet would be necessary. As we cannot count on such a head, especially for radiators on the ground floor, we have to figure on a larger pipe. With a 1½-inch pipe we can do the work with a head of 4.5 feet, which is about all that can be safely counted on in practice for ground floor radiators. This accords well with experience, as the writer has always found that a radiator of 100 feet on the ground floor needs at least a 1½-inch connection, and in some

cases it has been necessary to increase on this size before good results were obtained. This figures out practically the same as the rule given for steam pipes; by taking a maximum of 84 feet of surface off a 1½-inch pipe and using that as a basis for fixing the table of sizes, the figures are just the same as for steam.

APPLICATION OF THE RULE FOR DIFFERENT LENGTHS OF MAINS AND FOR DIFFERENT PRESSURES.—For each 100 feet (or fraction thereof) the mains are extended beyond 100 feet, use the ratio for one size smaller. Thus, if the plant required a 6-inch main for 100 feet, take the ratio of a 5-inch pipe for 200 feet and the ratio of 4½-inch pipe for 300 feet, and so on.

In the case of pressure the reverse method may be adopted, and for each two pounds pressure it is proposed to carry a ratio of one size larger pipe may be taken. Thus, if two pounds is to be maintained, a 9-inch ratio may be taken in place of 8-inch; if four pounds is to be carried, the ratio of 10-inch may be taken, and so on.

We have by this formula a simple rule that will meet almost any case found in practice, and while the writer does not claim that the changes of the ratio for the long pipes or higher pressure are mathematically exact, they are conservative and will be found to accord well with practice.

CONCLUSION.—It seems proper to offer some data to prove the correctness of this formula, and the writer desires to call attention to these facts. The ratio given for small pipes is ample, as can be demonstrated by hundreds of plants in use; that the sizes given for pipes from 1½-inch to 2-inch are larger than advocated by any previous writer, and they are twice as large as sizes given by Mr. Baldwin or Mr. Babcock; hence, we must assume that on these sizes the rule is safe. We then follow the rule till we come to a 3½-inch pipe, and we strike the same ratio as advocated by Prof. Carpenter, of .90 inches of ratio for each 100 feet of surface. At the 4-inch pipe we strike the rule of Mr. Baldwin and Mr. Babcock, and between the 8-inch and the 9-inch pipes we strike the ratio of .375, as given by Mr. Wolff. With a pressure on the pipes of ten pounds, on a plant requiring a 10-inch main, the ratio from this rule would be .21, as against that of .19 given by Mr. Wolff. By this we see that even on large plants the rule is within what has been found safe practice by skilled engineers.

DISCUSSION.

Prof. Carpenter: I want to congratulate Mr. Blackmore on his very excellent paper and on the neat way in which he has called attention to various rules. I wish, however, to say, partly in excuse

for my position and in excuse for the quotations which are made from my book on Heating and Ventilation, that so far as steam heating is concerned I did not intend that the rule of thumb that he has given should ever be used. I also, perhaps, should make the same explanation for Mr. Wolff, because I have had a very recent letter from him in which he not only wanted me to cut out his name in reference to the rule quoted, but wished me to substitute a table, which I did with a great deal of pleasure. In writing that book I attempted to gather together the various rules which were in common use, which I merely arranged in a certain form and found out what velocity of steam they corresponded to. Then I followed with a more exact rule which was deduced from Weisbach's formula for the flow of water and gave a table, for practical application. Now I have always advised the use of the more accurate rule or table. There has always been some question in regard to the table because it was based, not on the flow of steam, but on the flow of water. It has, however, proved from experience to be quite safe. Mr. Wolff has substituted for the rule which I gave in my book, a table which I take a very great pleasure in introducing, as a part of my discussion. The table that Mr. Wolff substitutes, is for a two pipe system, and I have calculated, a similar one for a one pipe system. I might say that since these two tables are calculated practically from the same formula, they, of course, substantially agreed. Now in practice I cannot see why we cannot usually turn to a table of this character: usually the proportioning of pipes is done in an office, and that being the case one has access to a table by means of which he can take into account the length of steam mains, the diameter and the radiating surface. All those things, as Mr. Blackmore has shown, have considerable influence on the results, and then we can get our results much more accurate. I know very well that my statements in the book on Heating have been misunderstood by others. I had a letter from Mr. Washburn, in which he stated that he was using those rules of thumb in exactly the manner described, although I had intended that they should not be used that way. During the last year and a half we have been engaged on experiments to determine the actual flow of steam through pipes with a given fall of pressure. Most of the experiments quoted are based on the flow of water through a pipe. I would say that probably the experiments on the flow of steam are finished as well as we can finish them. We have in our control only three or four hundred horse power of steam, and it takes more steam for entirely satisfactory results. I will write on the board the formula which we have found to best apply. The formula, you will find, is pretty complicated, but from

it it is easy to make a table and you can use the table readily. It is practically the same formula as given by Weisbach. There is nothing new in the formula except the coefficients, and the formula is as follows:

$$P = K\left(1 + \frac{3.6}{d}\right)\frac{w^2 L}{\square d} + \frac{1}{20.663}$$

The formula, you see, is a pretty complicated sort of thing. In this formula, P is equal to drop of pressure in pounds. That of course is a very important matter. W is equal to the weight of steam in pounds discharged per minute. L is equal to the length in feet or its equivalent. d is equal to diameter of pipe in inches. $\square$ is equal to the weight per cubic foot of the steam in pounds. If you use that formula you do not have a lot of tables. Now we found that with different sizes of pipe, from three-quarters to three inches, and with lengths up to 250 feet that the coefficient was practically constant within the limits of error or observation, and the constant lies intermediate between the constant for air and that for water as given by Prof. Unwin, which also seems to me to indicate that the work was correct. We can compute a table in which we shall have the amount of radiating surface carried by a given pipe of a given length from the formula. Mr. Sickles, who performed the experiment, computed a table which gives the number of pounds of steam which will pass through a given pipe of different lengths. That table is better suited for power purposes than for radiation, but of course it can be easily reduced to a radiation formula, since under ordinary conditions one pound of steam per hour will supply about three square feet of radiation. The formulas heretofore used have been obtained from flow of water, yet I find they do not differ very greatly from this. It has always been my practice in computing the steam mains to use the tables which have been computed for different lengths and for different diameters, counting elbows as equivalent to a length of pipe of a given amount. By the way, we made a determination of the friction on the elbows, globe valves and straight-way valves, which I believe give different results from those previously used. I think, for instance, we found an elbow to make as much friction as a pipe 520 diameters in length. I think it is frequently given as only about 5 per cent of that and we found that the globe valves were equivalent to 760 diameters of the pipe, but for gate valves the friction seemed to be negligible in nearly every case.

Mr. Blackmore: Is Mr. Wolff's table figured out for radiation?

Prof. Carpenter: Here is the table. For different lengths of pipe, he gave us a factor to multiply these results by. The table which I

have calculated is on a little different plan and I calculated it from different lengths. That is; I had lengths of 20, 40, 50, 100, 600, 1,000 feet. In this table I merely considered the commercial diameter of pipes, which are very much easier to be used and the table that I calculated was for the pressure with half a pound pressure and resistance of only 12 inches of water, which is practically what Mr. Wolff has used.

TABLE FOR THE CAPACITY OF STEAM PIPES WITH SEPARATE RETURNS.
100 FEET IN LENGTH. BY A. R. WOLFF.

Diameter of Supply. Inches.	Diameter of Return. Inches.	2 Lbs. Pressure.		5 Lbs. Pressure.	
		Total Heat Transmitted. B. T. U.	Radiating Surface sq. ft.	Total Heat Transmitted. B. T. U.	Radiating Surface. sq. ft.
1	1	9,000	36	15,000	60
1¼	1	18,000	72	30,000	120
1½	1¼	30,000	120	50,000	200
2	1½	70,000	280	120,000	480
2½	2	132,000	528	220,000	880
3	2½	225,000	900	375,000	1 500
3½	2½	330,000	1,320	550,000	2,200
4	3	480,000	1,920	800,000	3,200
4½	3	690,000	2,760	1,150,000	4,600
5	3½	930,000	3,720	1,550,000	6,200
6	3½	1,500,000	6,000	2,500,000	10 000
7	4	2,250,000	9,000	3,750,000	15,000
8	4	3,200,000	12,800	5,400,000	21,600
9	4½	4,450,000	17,[illegible]00	7,500,000	30,000
10	5	5,800,000	23,200	9,750,000	39,000
12	6	9,250,000	37,000	15,500,000	62 000
14	7	13,500,000	54,000	23,000,000	92 000
16	8	19,000,000	76 000	32,500,000	130 000

In above table each square foot of radiating surface is assumed to transmit 250 heat units per hour, a safe and conservative estimate.

For pipes of greater length than 100 feet multiply results in the above table by the square root of 100 divided by the length. In all cases the length is to be taken as the equivalent length in straight pipe of the pipe, elbows and valves, as given on page 226 of Carpenter's 'Heating and Ventilation." For other lengths multiply above results by following factors:

Length of Pipe...	200	300	400	500	600	700	800	900	1,000
Factor...........	0.71	0.58	0.5	0.45	0.41	0.38	0.35	0.33	0.32

For example, the capacity of a pipe 8 inches in diameter and 800 feet long would be 0.35 of 12,800 square feet of radiating surface = 4,480 square feet. It will be noted that the size of return specified by Mr. Wolff is about one pipe size greater than is believed to be necessary by the author, but sizes of main steam pipe are in substantial agreement with tables on pages 226 and 226b.

COMMERCIAL SIZES OF STEAM MAINS FOR A SINGLE PIPE. R. C. CARPENTER.

System of Heating by Direct Radiation: Pressure 0.5 lbs.; Friction resistance 6 inches of water for lengths 100 feet and under, 12 inches of water for greater distances.

Radiating Surface Sq. Ft.	Length of Steam Main, feet.								
	20	40	80	100	200	300	400	600	1,000
	Diameter of Pipe, inches.								
20	1	1	1¼	1¼	1¼	1¼	1¼	1½	1½
40	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1½	1½
60	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1½	1½
80	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1½	2
100	1¼	1½	1½	1½	1½	1½	1½	1½	2
200	1½	2	2	2	2	2	2	2½	3
300	2	2	2	2	2	2½	2½	3	3½
400	2	2	2½	2½	2½	3	3	3	4
500	2	2½	2½	3	3	3	3½	3½	4
600	2½	2½	3	3	3½	3½	3½	3½	4½
800	2½	3	3½	3½	3½	3½	4	4	5
1,000	3	3½	3½	4	4	4	4	4½	6
1,400	3½	3½	4	4	4	4½	4½	5	6
1,800	4	4	4	4	4½	5	5	6	7
2,000	4	4	4	4½	4½	5	5	6	7
3,000	4½	4½	4½	5	5	6	6	7	8
4,000	5	5	5	6	6	7	7	7	9
6,000	5½	5½	6	7	7	7	7	8	10
8,000	5½	5½	6	7	7	8	8	9	11
10,000	6	6	6	7	8	8	9	10	12
12,000	6	7	7	7	8	8	10	11	12
14,000	7	7	7	8	9	9	10	12	14
16,000	7	8	8	9	9	10	11	12	14
18,000	8	8	8	9	10	11	11	12	14
20,000	9	9	9	10	11	11	12	14	16

Mr. A. G. Paul: I would like to know what velocity the tables are based on.

Prof. Carpenter: Those are not based on any velocity whatever. They are based on the drop in pressure, or what we might call resistance, and this resistance is equal to 12 inches of water. That is, the water at the farther end of the system would stand 12 inches higher than next to the boiler. Mr. Wolff's, I think, is based exactly on the same resistance.

Mr. Kent: That is about a half pound pressure?

Prof. Carpenter: On half pound pressure, yes.

Mr. Kent: Mr. Blackmore says he assumes a velocity of 25 feet per second, "which is about correct for steam at atmospheric pressure." I would like to know on what data he bases that statement. In steam engines we proportion the exhaust pipe so that the velocity is about four times that. I do not see why for steam heating the velocity should be assumed to be only one-quarter of the rate allowed by steam engineers in proportioning exhaust pipes. I would like to ask Prof. Carpenter if he has made any experiments on the resistance of the bushings—whether there is not considerable resistance there due to the formation of the contracted vein.

Prof. Carpenter: We have some experiments on bushings, and

also on plain couplings, but the values can not be given at the present time.

Mr. Blackmore: In answer to the question about velocity, conditions are entirely different in a steam heating system from what they are in exhausting from an engine. In exhausting from an engine you are exhausting into the air or into a condenser. In a steam heating system, such as described here, the velocity is due entirely to the cooling power in the radiator. I got the data simply from studying such experiments as are given by Prof. Carpenter and others on the subject. While they all agree within a small fraction there is a difference; hence I used the term about 25 feet a second, because there is a variation.

Mr. Rockwood: I do not know how true that remark is that Mr. Blackmore made, but his remark suggests to me a fact that I do not think is generally realized—because practice is really contrary to the fact—that steam will go into a vacuum with much less resistance than it will go into the atmosphere—very much less resistance—so much less resistance that the exhaust valve of a condensing engine which would be plenty large enough to realize the same vacuum—within a very small difference—in the cylinder that is shown in the condenser, if that engine is run at high pressure, with the terminal pressure say above the atmosphere, it will create back pressure of two pounds higher when exhausting right, point blank from the cylinder. That is one illustration. Another illustration is the case of a compound mill engine of 225 horse power which has a 30-inch low pressure cylinder, a 4 foot stroke and runs sixty revolutions a minute. When that engine was put in, they formerly had a 24-inch cylinder instead of a 30-inch cylinder and an 8-inch exhaust pipe to their condenser, which was small, in my eyes, even for a 24-inch cylinder. How much too small then would it be for a 30-inch cylinder. I ridiculed the idea of leaving that pipe in with the cón-denser; but the manager wanted to make everything go as far as it would, so we left it in. I told him that he could demonstrate the disadvantage of it by following the course of a mercury column which I put up for him at various points. So it was put in, although we made arrangements for attaching a 12-inch exhaust pipe for this 30-inch cylinder, but actually used an 8-inch pipe, and what was my astonishment when I did not get a difference of a quarter of an inch on that mercury column from the condenser to the exhaust chamber? The practice is to make exhaust pipes for a condensing engine, very much larger than for an atmospheric exhaust. I suppose the reason is that the opposition of the atmosphere to the discharge of the blast makes back pressure. It seemed to me possible that that might ex-

plain the position Mr. Blackmore takes, that exhaust pipes should be larger for radiators which are going to discharge into the air. It will show that if there is nothing in the radiator but steam and the radiator exerts a suction, then it seems to me that the supply pipe of the radiator might be made smaller than it would be if there was an open discharge to the atmosphere.

Mr. Blackmore: I might say, in reply to Mr. Rockwood, that all the observations I have made have been wholly on low pressure work. I have not had an opportunity, except in one instance, to observe on exhaust steam where the exhaust steam is used for heating. Hence my calculations have not been made with reference to exhaust steam at all. They have been made with low pressure heating exclusively.

Mr. Kent: Respecting the formula that Prof. Carpenter has made on the assumed value of drop in pressure, I hope when he publishes his remarks he will make some statement as to what drop should be assumed for different cases. I wish he would give us some practical values of p, to be used in proportioning for different conditions.

Mr. Paul: I don't known that I can throw any light on the subject, but we have had considerable experience in regard to the size of pipe necessary to supply a heating system at atmosphere and without any back pressure on the engine, and I would say here that we have systems running, both low pressure, returning directly back to the boiler where there is only 18 inches between the main and the water line of the boiler in which we have taken 9,600 square feet of surface off a 6-inch main. We have others running where there is a 6-inch main supplying 10,000 feet of surface and that 6-inch main is 4,800 feet long. There is no drop at all. We do not show any vacuum on the system.

It seems to me that there is a factor which we have to take into account and that is the factor of the resistance of the air Mr. Rockwood has spoken of. The minute the system becomes a condenser, as he says, and the pressures are equal, it is only a question of supplying the amount of steam that your system will condense. If you remove the resistance of the air to start off with, you then are able to make your whole heating system a condenser; and, as he says, it requires a smaller pipe to do the same work on his condenser than what it did when he undertook to exhaust into the air. Now we have made a great many tests on systems, because we have taken systems that were run at 40 pounds pressure and reduced to atmospheric with the same size of pipe exactly and circulated them without pressure, without increasing the mains at all.

There is another question. Where is the economical point? In tests

that I have made lately it is a very grave question whether high velocities are economical. While we are able to circulate steam at a high velocity I am not sure to-day that it is any economy at all. I have made tests that would almost demonstrate that a lower velocity would be of considerable economy. Now those questions are still, to my mind, very uncertain. I only give these facts as to what can be done under certain given conditions merely to show the society that there are some factors there that we do not all of us understand.

Prof. Carpenter: In reply to Mr. Kent, I will say that this last year I designed quite a large system for exhaust heating in a factory, which was put in operation at the beginning of the year. I designed the piping for a resistance of 12 inches of water. I took p as equal to 4-10 of a pound, and the system has worked very excellently. Their gauges, of course, do not show any pressure at all. So it seems to me that practically 0.4 pound might be a very good limit. I think in the case mentioned by Mr. Paul there is really more difference in pressure than he imagines; in his system circulation is carried out below the atmospheric pressure. It seemed to me a remarkable fact, when I first looked into his system, that by simply removing the air from the radiator at the air valve, a vacuum on the radiator could be produced which might equal 18 inches. Eighteen inches corresponds to a difference of pressure of about ten pounds. Hence you would get an enormous suction through his system. So I think that the same rule will work for Mr. Paul's system, although it will need a good deal more experience to know just exactly what the conditions are.

Mr. Gormly: Mr. Blackmore deals with two subjects, the circulating of steam through pipes and also the circulating of water through pipes and the steam feature seems to be better discussed than the water feature. We have heard of exhausting steam into the air and the resistance of the air, but I think in looking at the water part of the paper there is something to be said of the resistance of air to the circulation of water. Now I believe it feasible if we could obtain compressed air cheaply to assist the circulating of the water heating plant by introducing compressed air into the vertical main. I have experimented a little in that line myself, and it seems to me that the movement of the water is increased wonderfully by the admission of very little air. I think if the vertical mains of a water plant were run directly from the boiler to the expansion tank, and air were admitted in the base of the vertical riser to carry that water nearly to the expansion tank, that we might get a movement four or five or possibly ten times as fast in the water of our circulating plant. I will illustrate that with compressed air in a glass tube. It is possible

at times to compress air very cheaply by a little apparatus which is called a beer pump, ordinarily, and water power is used to compress the air. It takes so very little air to make a wonderful difference in the movement of the water that I think it would probably be worthy of investigation. Now I will put a torch under here to make a natural movement in that pipe and then I will introduce air into the pipe. Now if you will notice the movement in this pipe is not very swift. (Mr. Gormly exhibited the operation of the apparatus.) I would like to know whether any of the gentlemen have experimented in that line at all?

Mr. Barron: Mr. Blackmore goes, I believe, into the rules given by Mr. Wolff and Prof. Carpenter and Mr. Babcock and some others. Now our practice to-day, of course, has been evolved from the experience of the steam fitters of the past, and the rules that Mr. Blackmore refers to are the rules that are deduced theoretically. I think that Mr. Blackmore neglects one consideration, that is the proportioning of the radiator surface that is in use, dividing the apparatus and taking the risers alone. If we take a radiating surface where it is proportioned largely in relation to the glass exposure and wall surface exposure and air, etc., if the radiating surface is put in very large, the riser, in proportion to the radiating surface, of course, relatively does not have to be so large to work satisfactorily. At this time of year we have a good deal of experience in heating buildings for workmen; that is, practically in drying plaster. In those conditions the radiators fill up with water generally, because of the riser being too small. The risers being simply proportioned for ordinary working conditions are not large enough for carrying steam to the radiating surface and taking the water away. I think Mr. Blackmore neglects those considerations in his paper.

Mr. Backmore: In reply to that no one can lay down a rule for all the conditions met with in practice. The only thing we can do is to assume average conditions, which I have done in this case; that is 100 feet of radiation losing 255 units of heat per hour per square foot. If the radiator is made to cool double that, of course, you have got to double your pipe to get the same results. If you put in more radiation, then I think you will cool so much less per square foot and the pipes need not be as large for the amount of surface on the system. No one can lay down rules for anything of that kind.

XLIII.

THE EFFECT OF THE HEIGHTS OF WALLS ON THE AMOUNT OF HEAT TRANSMITTED THROUGH THEM.

BY J. H. KINEALY, ST. LOUIS, MO.

(Member of the Society.)

It is known, as a result of experiment, that the heat which passes per hour through a wall separating a hot fluid from a cool one can be expressed by the equation

$$Q = k (t_1 - t_2) S$$

in which Q is the quantity of heat, in heat units, transferred per hour from the hot to the cool fluid; k is a factor whose value depends upon a consideration that will be discussed later; t_1 is the temperature of the hot fluid; t_2 is the temperature of the cool fluid, and S is the area, in square feet, of the surfaces of the wall in contact with the hot and cool fluids.

The experiments of Peclet and others have shown that the value of k depends upon the nature of the hot and cold fluids; upon the separating wall, the nature of its surface, the materials of which it is made, its thickness and its figure; and somewhat upon the difference $t_1 - t_2$. The value of k depends upon two things, the loss of heat by radiation, and the loss by direct contact. The loss by radiation depends upon the temperature, t_2, of the surrounding bodies, and the loss by direct contact depends upon the temperature of the air in direct contact with the separating wall, which may be higher or lower than the temperature of the surrounding bodies. The greater the difference between the temperature of the warm fluid and that of the cool air in direct contact with the separating wall the greater will be the loss by direct contact and the greater will be k for a given value of t_2; and the less this difference the less will be the loss by direct contact and the less will be k.

Peclet made a great many experiments from which to determine the value of k. Most of his experiments were made with steam or hot water as the hot fluid and air as the cool fluid. When steam was used the temperature t was uniform throughout the hot fluid,

as it depended simply upon the pressure of the steam; and when water was used it was kept agitated, so that it would have as nearly as possible a uniform temperature throughout. The temperature, t_2, of the cool air surrounding the radiator containing the steam or hot water was measured at some distance from the radiator and not directly at the surface of the radiator. As a result of his experiments Peclet found that, for the same value of t_1 and t_2, k was less for a high wall than for a low one of exactly the same material and thickness. The explanation for this is that as the air in contact with the separating wall is heated it rises along the surface of the wall; and as it rises it continues to be heated until finally, when it reaches the top of the wall, it is much hotter than it was when it was at the bottom of the wall. The higher the wall the higher will be the temperature of the air when it reaches the top, and, therefore, the higher will be the average temperature of the air in contact with the surface of the wall. The higher the average temperature of this air the less will be the average difference between its temperature and that of the steam, and, therefore, the less will be the amount of heat lost by direct contact of the air and the less will be the value of k.

The conclusions arrived at by Peclet through his experiments are corroborated by experience. It is well known that the air leaves a high radiator at a higher temperature than it does a lower one, when both are supplied with steam at the same pressure, and that a high radiator loses less heat per hour per square foot of surface than a lower one.

I find that many French, English, and American writers, reasoning, apparently, from the results of Peclet's experiments, and from experience with radiators, say that the value of k for a high wall or window of a building will be less than for a lower one of the same kind and thickness. Some writers make the deliberate statement that a high wall or window will transmit less heat from a room, with given inside and outside temperatures, than a lower one of the same kind, area, and thickness. This, I contend, cannot be true, as it is based upon an assumption of conditions that are never realized in practice.

The air on the outside of a wall or window of a heated room is of almost a uniform temperature. It is hardly probable that, on a cold day, when the wind is blowing, there is any appreciable current of warm air rising along the outside of the wall or window of a heated building. I have never been able to detect such a current on a cold day; and yet such a current of warm air is supposed to exist by many writers.

The temperature of the air inside of a heated room is not uniform

at different heights from the floor, but is least near the floor and gradually increases towards the ceiling, where it is greatest. So far I have been unable to establish any law for this increase. It depends upon the outside and inside temperatures and upon the method of heating. It is greater in cold weather than in mild weather and is greater for a hot air system than for direct steam or hot water radiation. It may depend, also, upon the part of the room at which the temperatures are measured. That the air near the ceiling of a heated room is much hotter than that near the floor is well known to all who have had occasion to stand on a step-ladder in a warm room. Hence the conditions that actually prevail in a heated room are:

A uniform temperature of the air on the outside of the wall and a gradually increasing temperature from the floor to the ceiling of the air on the inside. And for a temperature of about 70 degrees four or five feet from the floor the average temperature of the air inside of the room increases as the height of the wall is increased. Therefore, the higher the wall or window surfaces of a room the greater will be the amount of heat lost per hour through them, and the greater must be the value of k used in the formula for calculating the heat lost.

German engineers, as a rule, increase the calculated heat loss for rooms whose exposed walls are higher than 10 or 12 feet by an amount which depends upon the height of the walls.

J. H. Klinger, in his pocket-book for heating engineers, advises that the calculated heat loss of a room be increased by three per cent of itself when the walls are between 13 and 14½ feet high; by 6.5 per cent when they are between 14½ and 18 feet high; and by ten per cent when they are higher than 18 feet.

H. Recknagel, in his pocket-book for heating engineers, advises that the calculated heat loss of a room be increased by ten per cent of itself when the walls of the room are more than 13 feet high.

H. Rietschel, in his treatise on heating and ventilating, calculates the temperature of the air at the ceilings of rooms, when their heights exceed 10 feet, by the formula

$$t_1 = t + 0.03\,(h - 10)\,t.$$

t_1 is the temperature of the air at the ceiling; t is the temperature of the air about five feet from the floor or "head-high," as Rietschel says; and h is the height of the room from the floor to the ceiling.

He takes the average temperature of the air in the room as

$$\frac{t_1 + t}{2} = t + 0.015\,(h - 10)\,t.$$

If the height of the room is less than 10 feet, he takes the temperature at "head-high" from the floor as the average temperature. The temperature t_1 must never be taken as greater than 1.3t.

Rietschel uses the average temperature of the air in the room when calculating his heat loss. The writer has found that the increase of temperature of the air in a heated room varies from one-half to two degrees for each foot of height above the floor, and that for rooms whose heights are about 12 feet the average temperature of the air may be taken as equal to the temperature measured 4.5 or five feet from the floor. When a room is heated by hot air it is probably safe to say that, when the temperature of the air in the room is 70 degrees five feet above the floor, the temperature at a distance h from the floor is about $65 + h$. If h is taken as the height of the ceiling above the floor, the average temperature between the floor and the ceiling is about $65 + \frac{h}{2}$.

For work in connection with ordinary dwellings or schools it makes very little difference whether a high wall or window transmits more or less heat per hour than a lower one of the same kind and thickness, as the walls of the rooms are usually not much higher than 12 feet, and the average temperature of the air is about the same as the temperature observed about 4.5 or five feet above the floor. But for work in connection with churches and other buildings, in which the heights of the rooms are quite great, it becomes important to know whether the heat loss of a high wall is or is not different from that of a lower wall of the same kind, area, and thickness; and if the heat loss is not the same for the high as for the lower wall, it is of the utmost importance to know whether it is smaller or greater.

Writers on heating seem to have divided themselves into two classes; those who consider that the high wall transmits less heat and those who consider that the high wall transmits more heat. I am inclined to think that the second class is the smaller, yet I am sure that their view of the matter is the correct one; the high wall transmits more heat than the lower one.

My attention was first called to the different opinions of engineers on this matter by the editor of one of our weeklies running his blue pencil through an article I had written, in which I stated that the heat loss of a high wall is greater than that of a lower one of the same kind, area, and thickness. As you all know, an editor, armed with a blue pencil, may be an exceedingly inconvenient opponent, but I had the temerity to try to convince him that I was right, and finally succeeded in having the blue pencil-mark erased.

If, now, I have succeeded in convincing the members of the society that my position in the matter is the correct one, this paper will have accomplished its object.

DISCUSSION.

Prof. Carpenter: I am much interested in the paper submitted by Professor Kinealy, and I fully concur with his opinion that the loss of heat of walls is not inversely proportional to the height; indeed, I am willing to go very much further than this, and to state that I do not believe that there are any experiments in existence which show that such is the case.

A study of the experiments as made by Péclet do not seem to indicate any such results. His experiments on heated surfaces do show a decrease in coefficients of heat transmission which varies with the square root of the height, and which we know now to have been due to the fact that the temperature of the air surrounding the upper portion of the heated body was higher than that near the bottom. In case of the walls of buildings the air is freely removed and hence there is not found a stratum of warm air near the upper portion; indeed, in many cases the conditions are reversed, and colder air is found near the upper portion of the building. It strikes me that this is shown distinctly by Péclet's own experiments. He, however, unfortunately made an error when he came to apply the results of the experiments to practical cases of buildings, in that he considered the building coefficient of loss to diminish in the same manner as that from heated vertical pipes surrounded with still air. Box in his practical treatise on heat made a literal translation of Péclet's experiments and deductions, and also added considerable new matter, thus not only perpetuating but emphasizing the error.

It has recently been found (See Theory of Heat by Preston) that the coefficients of conductibility for metallic bodies as determined by Péclet were in error six times, that is, they are six times too small. This fact alone seems to make the whole application of any theory like that discussed by Professor Kinealy not only absurd but actually misleading.

In my book on Heating and Ventilation I introduced the modern coefficients in every case where they differed from those given by Péclet, but I did not suggest the application of the complicated rule discussed by Professor Kinealy for the reason which I have just mentioned.

Practically we find that the coefficients of heat transmission through walls is much the same for the same class of buildings,

whether the material be brick, stone, or wood. This condition of equality is insured by using composite walls in all the different classes of buildings. In the brick building we find air spaces, and in the wooden buildings double layers of thick paper, making them practically as warm in the one case as the other.

Another important matter which is entirely neglected in the paper by Professor Kinealy is the heat required to warm the air which enters the room, possibly inadvertently, but always in sufficient quantity to sensibly affect the results.

The simple fact which was determined by Péclet and verified by recent experimenters that the wall of a building 12 to 16 inches in thickness would transmit approximately one-quarter as much heat as a single thickness of glass, and that under ordinary conditions a square foot of glass would transmit one heat unit per hour for each degree of difference in temperature between the air in the adjacent spaces, seems to be about the extent of our accurate knowledge in this line of inquiry. The total loss is obtained by multiplying by the number of square feet of exposure. Unless the amount of air which will pass adventitiously into a room is known absolutely, it seems entirely unnecessary and useless to attempt a more elaborate calculation for the loss of heat from buildings. This fact is also accentuated by the great difference which exists in different buildings of the same class, which difference is sufficiently great to prevent any extreme accuracy in calculation. It seems to me better to figure for an average case and then to make allowances by inspection and judgment for various conditions. The method employed by Mr. Alfred R. Wolff is in my opinion to be commended in this respect.

Mr. Kent: I would like to ask Prof. Carpenter if he does not consider that K in this formula is a constant for a given wall and does not depend on a difference in temperature for top and bottom; that it is a coefficient for conductivity alone and is a constant for a given wall? On page 3 of the paper it is said that the higher the wall the greater must be the value of K. Should it not be the greater the value of the difference of temperatures? That is we may have a room in which the average temperature five feet from the floor is 70 degrees and zero outside, but if it is a very high room and it is 90 at the top of the room, then the mean difference should be, say, 80.

Prof. Carpenter: Péclet's experiments, as will be found by studying them, were all confined to tests of heated surfaces surrounded by still air, and he found quite accurately for such cases that the average heat transmission per unit of surface decreased with the height. I think that Professor Kinealy should have given more information in regard to the formula used, otherwise it is certain to

be deemed incorrect. When used under special conditions it is not however erroneous. These conditions, as explained by Péclet, are as follows:

First. The heat transmission through a given wall in which C is the coefficient of heat transmission, t the temperature of the inner surface of the wall, t' the surface of the exterior surface of the wall, e the thickness, T the temperature of the medium on one side of the wall, θ the temperature outside of the wall, C the coefficient of conductivity of the material of the wall, Q is the coefficient of heat transmission and is equal to that transmitted both by radiation and conduction.

By combining these various equations we obtained the following:

$$M = \frac{C\,(t - t^1)}{e};\; M = Q\,(T - t);\; M = Q\,(t' - \theta);$$

$$t = \frac{T\,(C + Qe) + C\,\theta}{2\,C + Qc};\; t' = \frac{\theta\,(C + Qe) + TC}{2\,C + Qe};\; M = \frac{C\,(QT - \theta)}{2\,C + Qe}.$$

The last formula is the only one which can practically be applied, since it is impossible to determine the temperatures of the surfaces. It will be noted that if Qe is very small relatively to 2C it could be neglected, and this latter formula would reduce to

$$M = \frac{Q}{2}\,(T - \theta).$$

This is essentially the form as given by Professor Kinealy, in which (k) is substituted for Q divided by 2, and it is, as will be noted, above, nearly accurate for thin bodies. For thick walls it is very inaccurate, and is not used by Péclet, so far as I have been able to find. The average loss he assumes to decrease slightly with the height, which assumption does not seem to have been checked experimentally.

Mr. Blackmore: I owe Thomas Box a debt of gratitude. I also blame him for some of the errors I fell into some years ago. Almost the first book I got on the subject was Box on Heat. I studied it very carefully. The difference in the loss between high walls confused me quite a good deal. However, as Mr. Box put it down as coming from Péclet, I took it as sound and accepted it. I remember quite a few years ago one instance—it always has been our practice to reduce the radiation as we go up on each floor. But I had a case where it was absolutely cut off from the floor below and very little heat could pass through. I met with a rude shock, as may be expected. I reduced the radiation, and these upper rooms did not heat, much to my surprise. I studied Box very carefully, and I found that according to him I was correct, but it didn't work. I

have come to the conclusion that Prof. Kinealy is absolutely correct, that a high wall wil lose more than a low one.

Mr. Meyer: I would like to ask Prof. Carpenter whether it is safe to assume that the temperature of the wall next to some medium, such as the air, can be assumed as the same temperature as the air itself. In other words, in using this formula of Prof. Kinealy, have you got a right to take the inside and outside temperatures?

Prof. Carpenter: This formula cannot refer at all to the temperature of the room or the temperature of the outside air, except in the sense described, and by using Péclet's special coefficients. It is in serious error when used for transmission through walls.

Mr. Meyer: I think it has been taken that way a number of times.

Prof. Carpenter: The original equations are those just stated. Prof. Kinealy's formula applies to buildings only when the thickness corresponding to a given value of *K* is known.

Mr. Meyer: I do not see how people are going to use the formula unless they know what it is worth.

Prof. Carpenter: Péclet gives in his original work a value of *K* for walls of different thickness, thus making K a special coefficient.

Mr. Barron: Taking an engineer who is getting plenty of time and a large price for designing a plant, does it pay to go into all the minutiæ of Péclet? Is the practical value to the engineer very high? My experience is that either architects or engineers when they design anything have a very large percentage of allowance to cover odds and ends, all the way down from 10 to 30 per cent. additional over what an ordinary contractor would guarantee to heat a building for. Scientific reasoning is, of course, exceedingly valuable, but what we look at here is its practical value. Do you use such theories practically in designing the building you just spoke of?

Prof. Carpenter: In regard to the question raised by Mr. Barron and the general question, I would say that these very elaborate rules given in this way I think are of no value whatever, for the reason that they are based on theoretical considerations that have never been proved by experiment to be true, and I do not use them. I do, however, use a very simple way of getting at an estimate. I can get it almost as quickly by a way that is nearly accurate as most people can by applying a principle that is not even approximately true. However, I won't say that I can beat practical men for accuracy with it, for I know better than that. But I have found out by comparing my estimates with the estimates of very reliable people that they usually get almost exactly the same quantities in a dif-

ferent way. A practical workman, for instance, doing business with a certain class of buildings in a certain locality, gets to know by his experience, approximately what heating surface he has to put in. But let that man go into a different class of buildings, a different locality, and he will come out very badly. The method that I have invariably used for residences is very accurate, but for other classes of buildings I am somewhat at sea on account of uncertainty regarding the amount of air. My method is this: I have counted four square feet of wall surface as equivalent to one of glass. I have simply scaled from the architect's drawing the number of square feet of glass and the external wall surface, in square feet, using a slide rule for computation. In heat with direct steam radiation, you need practically as much direct radiation as is equal to one-quarter of the external wall surface, plus the window surface to overcome loss of heat from the walls. We have also to introduce heat for warming air. Air which comes into the building goes out. I have found out by comparing the method with actual experience that you can count on the air changing in an ordinary sitting room of a residence heated with direct radiation about twice an hour, in spite of everything you can do. It will change in halls about three times an hour; in chambers or sleeping rooms, which are closed during the day and not used so constantly, and generally in upstairs rooms in ordinary small residences, once per hour. We have to put in an additional amount of radiation to warm up that air, say one square foot of radiation for every 200 cubic feet of air that you heat in an hour. I have a simpler rule than that of getting at it. But that is what is amounts to. In residence work I have had excellent success. In proportioning radiation for store buildings and other buildings of that kind, I have had sometimes a difficulty in estimating the amount of change of air, and it perhaps depends a good deal on the nature of the building. For an office building, I think we are pretty safe in assuming three changes of air an hour. Mr. Washburn and I have had some correspondence regarding some heating he did last year, where some store buildings were heated, and I believe that he found that when he estimated on a change of air twice an hour, it had to be increased. It had to be brought up to about three times, which gave us some data on that subject. I believe in the case mentioned the amount of radiation had to be put in greater than any one estimated. I estimated for two changes; an architect's estimates by his ordinary rule of thumb, and our original estimates were not far apart. But the radiation had to be increased. Really my method is a very quick one. It takes only a few hours to go over a pretty good sized

building—about as quick as you can compute the cubic contents. My rule is:

Rule.—For heating to 70 degrees in zero weather, direct heating, radiating surface is equal to the sum of the glass surface plus ¼ the exposed wall surface, plus* 1.55 to 3.55 times the cubic contents, for rooms as explained, multiplied by ¼ for low pressure from steam heating or by 0.4 for hot water heating. I also use the following:

Rule.—The radiating surface is equal to the glass surface, plus ¼ the exposed wall surface in square feet multiplied by the following factors:

	Steam Heating.	Hot-Water Heating.
First story......................	0.7	1.05
Second story....................	0.6	0.9
Third story.....................	0.5	0.8

*1.55 corresponds to one change of air per hour, 3.55 to three changes of air per hour.

Note.—In direct heating air will change once per hour in sleeping rooms and rooms little used, twice per hour in sitting and living rooms and ordinary offices, three time per hour in halls, stores and offices, with many entering and leaving.

In indirect heating, excess of air seldom has to be considered, but in case extra air is needed for ventilation, add one square foot of radiation for each 200 cubic feet of air in steam heating and 125 feet in hot water heating to warm up that air.

Mr. Barron: I do not know whether I can confirm practically Prof. Kinealy's statement or not, but I know that for many years we have heated many flat buildings of five stories in which the rooms are the same all the way through the buildings. On the upper floors we have to put the radiators larger, for there is a gradual change throughout the building, and it reaches a climax at the top. I know that a radiator on the second floor is not large enough for the top floor. That is the experience with a great number of buildings uniform in size and radiation and in the size of the risers and in the whole plant. That would seem to confirm in my mind that Prof Kinealy is right about the loss of heat.

Prof. Carpenter: Isn't there more wall surface on the top of the flat? Do you not have a roof surface exposure?

Mr. Barron: We have, but that is pretty well protected. There is an inner and outer roof and a space between. We have actually a little more exposure. There is no question about that.

*From Heating and Ventilation of Buildings, p. 216.

XLIV.

SINGLE PIPE LOW PRESSURE STEAM HEATING SYSTEMS.

BY MARK DEAN, BOSTON, MASS.

(Member of the Society.)

Single pipe systems for low pressure steam heating may be divided into three general classes, each with variations; the up-hill system, the drip system, and the circuit system. Believing the latter to be the best, it will be the one discussed in this paper. But, regardless of the system adopted or rules given, the heating engineer must employ active common sense in order to meet the requirements of each individual case. I do not mean to depreciate the value of rules and formulæ; on the contrary, I believe they are necessary, but on account of varying conditions it is impractical to make a rule that will cover all cases. The statements made and formulæ given in this paper are based on ordinary conditions—the average building as we find it to-day supplied with commercial cast iron direct radiators and heated to 70 degrees F., with an outside temperature of zero.

As the size of the pipe depends upon the work it is to do, we must know the size and location of each radiator, because from the total condensing power we get the size of the main steam pipe, and the size of each branch is also computed from the amount of radiation it is to supply.

The requirements of the steam main are three-fold; it must be large enough to carry, at low pressure, sufficient steam to supply the total radiation, carry the condensation, and maintain at its extreme end a pressure equal to the initial pressure at the boiler. To find the size of pipe capable of fulfilling the above requirements divide the number of square feet of radiation to be supplied by 100, extract the square root of the quotient, and the answer will represent in inches the diameter of supply pipe. Thus,

$$\sqrt{\frac{R}{100}} = D$$

in which R = the number of square feet of radiation to be supplied and D = the diameter in inches of the main supply pipe.

When the answer is a fraction of a pipe-size the next larger size should be used, and pipe smaller than 2 inch diameter should not be used for mains.

Branches.—Requirements of branches differ from those of mains, because the water of condensation returns to the main against the flow of steam. Therefore they not only supply sufficient steam for all radiation attached to them, but must do so without allowing the steam to attain sufficient velocity to impede the flow of the return water. To determine the maximum velocity at which steam may travel in branches having a rise of not less than one inch in four feet (if they are even given less, one size larger pipe should be used), multiply the external circumference of the pipe by $1\frac{1}{2}$, and the answer will be the number of lineal feet per second, faster than which the steam should not travel. Whenever the branches have an incline in excess of 45 degrees the velocity may be increased to double the external circumference of the pipe, dropping all fractions from the answer, which will be the maximum number of lineal feet of steam travel per second.

To ascertain how much radiation any branch pipe will supply at velocities given above, use the following formula:

$$\frac{V}{L} = C; \quad C\,\frac{.0387}{.00007} = R$$

in which V = the velocity of the steam per second,

L = the length of pipe containing one cubic foot,

C = the number of cubic feet of steam delivered per second to radiator, and

R = the number of square feet of radiation supplied.

The following table, giving the size of pipes, velocity of steam, and amount of radiation supplied, differs somewhat from general practice in the amount of radiation supplied by some pipes, but I believe it to be correct.

Table A.

Size of Pipe.	External Circumference of Pipe. Inches.	For Pipes Having an Incline of not less than one inch in four feet.		For Pipes Having an Incline of not less than 45 degrees.	
		Velocity in ft. per sec.	Sq ft. Radiation Pipe will Supply.	Velocity in ft. per sec.	Sq. ft. Radiation Pipe will supply.
¾	3.299	4.948	10.11	6.598	13.48
1	4.131	6.196	20.51	8.262	25.88
1¼	5.215	7.822	44.80	10.43	59.16
1½	5.969	8.953	70.04	11.938	93.37
2	7.461	11.191	144.18	14.822	191.09
2½	9.032	13.548	248.67	18.064	332.26
3	10.996	16.494	467.64	21.992	623.07

When the temperature to be maintained is less than 70 degrees deduct from the amount of radiation to be supplied by mains or branches as given herein, 1½ per cent for each degree drop in temperature.

After having ascertained the size of mains and branches they should be located on the plan beginning at the boiler with the main supply pipe, which should rise immediately to its highest point, whence it should have a gradual descent of not less than one-half of an inch in ten feet to its extreme end. If there is a tendency for the expansion to work the pipe towards the boiler, the pipe above it should be braced to prevent any movement of it and thereby prevent straining the boiler. On large jobs, and sometimes on small ones, it is desirable to reduce the size of the main pipe. Whenever this is done,

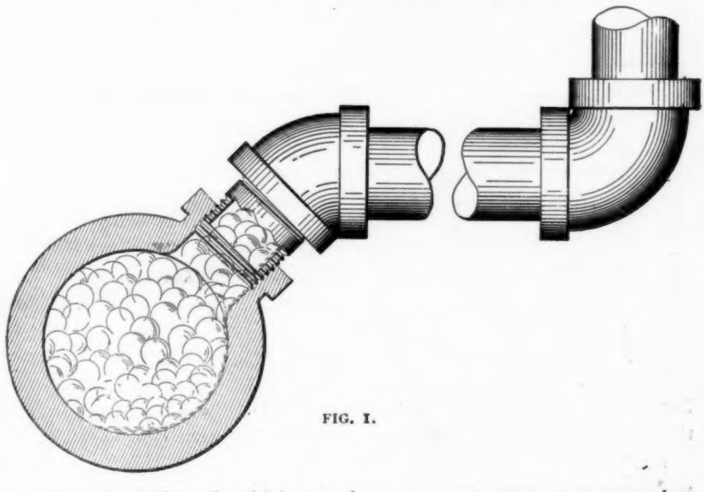


FIG. I.

an eccentric fitting should be used, so as to prevent a water pocket. When calculating the size of main pipe beyond a reducer allow sufficient area for water of condensation from branches already passed, plus sufficient area for steam for all branches yet to be supplied. It is not advisable on small jobs to reduce the size of main pipe, except in special cases. All mains should be carried at least two feet beyond the last branch, where they should empty into a return pipe through a drop connection, so as to leave no water in the pipe. From this connection the return pipe should be extended to the boiler above the water line and there dropped down to the return opening in the boiler. There should be a combination (for either steam or water) automatic

air on the end of the return pipe above the water line. When conditions prevent placing the return pipe overhead it may be run below the water line. The return should always have a drain cock at its lowest point. For returns 1-inch pipe should be used on jobs having 500 or less square feet of radiation. Increase the pipe-size one-quarter of an inch for each additional thousand square feet of radiation or fraction thereof. The mistake of making the main too small and the return too large is very common.

Branches may be taken off the main from the top, side, or any angle between the top and side. The best connection is made by turning the tee about 45 degrees upward into a close nipple, 45 degree bend, and branch pipe, as shown in Fig. 1. It will be observed that this style of connection takes the steam from near the top of main and returns the water to the bottom. By using a pitch ell at the bottom of the riser this connection will give the desired grade to

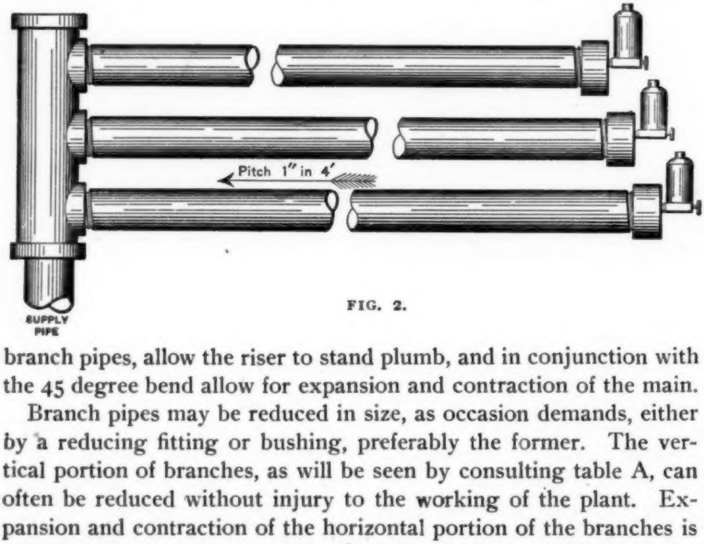


FIG. 2.

branch pipes, allow the riser to stand plumb, and in conjunction with the 45 degree bend allow for expansion and contraction of the main.

Branch pipes may be reduced in size, as occasion demands, either by a reducing fitting or bushing, preferably the former. The vertical portion of branches, as will be seen by consulting table A, can often be reduced without injury to the working of the plant. Expansion and contraction of the horizontal portion of the branches is generally too slight to require attention, but when an allowance for it is necessary, it can generally be made by an offset in the pipe. If the radiator is too close to a riser that will expand upward, connect to the end of the radiator farthest from the riser. Large radiators, the internal connections of which are of less capacity for the amount of radiation they contain, than the pipe sizes recommended in table A should not be used. I hope the day is not far distant when all large radiators will be put together with large openings between the loops.

If coils are to be used instead of radiators connect them in the manner illustrated in Fig. 2, i. e., single pipe system. It will be noticed that only one header is used, there being an air valve on the end of each pipe. The saving of fittings and labor more than compensates for the extra air valves, which should be of some pattern that can be used either as automatic or straight. The superiority of this arrangement for moderate weather is quite obvious. The writer's experience in low pressure heating leads him to the belief that, after having properly proportioned and graded the pipes the less complications the better.

DISCUSSION.

Mr. H. D. Crane: The paper describes what we are using extensively in the western country, and as far as the author has gone it is correct, but it seems he has not mentioned anything relative to the branch pipes with which we have at times experienced considerable trouble in attempting to run them a greater distance away from the main than 14 feet. We have established the distance that we carry our branch pipes in a one pipe system at 14 feet. There are cases where it would be more economical to carry them farther along, on account of walls or some other obstacle in the basement, and not make an offset, because we may have connections located at a distance of about 18 feet away. The practice then is to form a loop, taking the pipe off the top of the main, carrying it around and bringing it into the side of the main at any convenient distance, and to treat this loop in the same manner as our main. The connection shown in Fig. 1 is one that is commonly in use and probably is the best that we have found for the purpose. The paper states that they can be taken off of the side. That is poor practice and is apt to flood the line from the main to the vertical riser. For some time we have considered it the better plan to increase our size of pipe from our riser to our main, if the distance is from 10 to 14 feet, but it is preferable to run the main line of pipe about 4 feet from the risers. We get better results in that way, the L turning to the vertical line; we use what we call a pitched L that has one opening which is upon a line with the vertical riser,and that facing the main line a degree or two off of a right angle with the riser.

Mr. Barron: Would Mr. Crane kindly explain the single pipe system in relation to exhaust heating?

Mr. Crane: We, of course, use exhaust wherever we have it to use, but we have had better results by going direct to the attic; that is, we carry the main line unobstructed to the attic and then bring the distribution down from that point. We also treat the hot water

in the same way; carry the main line down through and connect from the riser with the T, running it over into the top of the radiator and on the same side of the radiator come back into the riser again from the bottom, and find that we can pipe jobs in that way with less friction, although it is a roundabout way. But it certainly is forcing all of the air and water of condensation ahead of the steam and it gives better results all over the building; and that practice I think now is being indulged in probably more than what we call the basement plan, although the basement circuit of pipe requires a little larger pipe than that of the attic; but the difference in expense is probably, I would estimate, about 5 per cent. greater for the overhead system of piping than the basement circuit.

There is one advantage in connection with this system—we do not use any expansion joints at any point in our work; it doesn't make any difference if we have even a sixteen story building. Generally we suspend the pipe at the center. We expand both ways and we provide for expansion by running over the floor to our radiator, and our expansion in our vertical lines, either in the attic or in the basement, is provided for by the arrangement of the branch. I would like to say that in our attic circulation we take the T off the bottom and run our line practically level. Then, of course, as you can readily understand, it becomes a relief.

Prof. Carpenter: I wish very much that the rule which is given on the second page could be explained. The area of radiation seems to come out very closely with that which is ordinarily adopted; but I cannot see any philosophy whatever for that rule. If there is no philosophy for a rule, of course the rule will fall when you go beyond the actual cases to which it is applied. For instance, if you were to extend this to 6 inch pipes it might give absurd results. It seems to me that there ought to be some reason or experiment showing why that rule is used. The results given in the paper are certainly not unreasonable. Now so far as the motion of steam through pipes is concerned, the velocity with which it will move depends entirely on the drop in pressure. We know for instance if we made the drop in pressure equal to two-fifths of the absolute steam pressure the velocity will exceed 1,500 feet per second. That is simply the velocity at which the steam will move under that difference of pressure. Of course, steam will be somewhat retarded by friction in moving through pipes. So I cannot see any reason for the author's statement regarding velocity, and I should like to have the reasons given in full for the use of the rule and also to have it shown whether or not the rule is general and will apply to every case, or whether it is an empirical rule limited

simply by his experience in proportioning radiating surface. This is a point that is not made clear in the paper.

Mr. J. A. Connolly: I would like to interrogate Mr. Crane on two points. He stated that the maximum horizontal branches were 14 feet. I would like to know the incline. I would also like to know if Fig. 2 is common practice in the western country?

Mr. Crane: I made the statement that every 10 feet we usually increased the branch back to the main from the riser. We found by experience that that was about as far as we could run. I do not think that there are any scientific data on that subject or that I could explain it you in any other way than that it does it. It succeeds up to 14. Beyond that you are not liable to make a success, and I generally go to the limit. I want to explain to you how you could save some money in a practical way by forming this loop, but I warn you against taking your connections off the side, which is a mistake that I once made. As to Fig. 2 I never saw a coil connection that way. Probably it is all right.

Mr. Andrew Harvey: In regard to the one pipe system, I differ a little from Mr. Crane about the economy of carrying steam up to the fifth or sixth floor and then coming down to heat the first floor. My experience has been in using exhaust or very low pressure steam that the most economical way was to put the main large enough in the basement and then run up risers to the different stories and then supply each as it went up. It always seemed to me more like following nature that way; whereas carrying the steam pipe up 100 feet high and then coming down 100 feet to heat the first floor, which is usually the coldest—the store floor—would be a little bit off. I have taken a number of buildings that have been fitted up and just reversed the action, putting in a larger main of course—and the result I found was more economical and gave better satisfaction. Still there have been many jobs done with the one pipe system carried up to the attic of the tenth and twelfth floors. At the same time I do not think it is good practice.

Mr. A. G. Paul: I might make a statement in regard to some conversation we have had on the question of keeping water out of a radiator, as between the up-feed and the down-feed. The tendency of steam flowing at high velocity from an attic main down, carrying in suspension a certain amount of water, is to throw the water in the direction that the steam is flowing down the riser. As a consequence you get practically a separator, and I think that on a down-feed job you will find that you will get very much drier steam in your radiator than you can get in any up-feed job.

Mr. Crane: I was of the same opinion as my colleague from

the West, Mr. Harvey, until I met a man who convinced me of the contrary, and I think if he will come down to Cincinnati I will convince him of the contrary. Is it not a fact that all cooling bodies descend; that is to say, if we introduce our steam at the top of a roof doesn't it immediately commence to cool and hasn't it a tendency to fall? and certainly our water has the same tendency and the steam and the water and the air all travel in the same direction, making harmony. Whereas if the steam was ascending and the water attempting to descend and the air to get out through the Paul system or some other system, we have two elements there that are conflicting. A few experiments that were made with a riser, and which I believe has been stated by authority, show that in a one pipe system the water does not go down the pipe in the shape of a cataract, but it confines itself to the side of the pipe and that the steam passes up through the center of the pipe. But as soon as the pipe becomes so small that the velocity of the steam passing up to supply the condensation is excessive, there is a tendency for the steam to lift the water and to keep it in the main rising and falling until by its weight it is carried away. I have a case in mind where an apparatus of that kind was placed in a building, and it was discovered that the risers were too small and it became necessary to change them. But a gentleman whom probably many of you knew—Mr. Frisbie, now dead—undertook to make the change by going to the attic. It was so constructed that it was impossible for him to change the risers. He went to the attic with the feed and used the mains in the cellar for the return pipe. By a few changes the remedy was applied. The risers were all right. They circulated without any noise, without any of the lifting of the water in the risers, which convinced me that the system of going to the attic was the preferable one. Although I have not visited the extreme West I believe the majority of the jobs now are planned from that idea.

Mr. Andrus: In regard to a coil with automatic air valve, some years ago I heated a church in New York and carried lines horizontally from near the pulpit back through under the pews, and under a division of each seat a line of inch and a half pipe on each side; they were 40 feet in length and worked with an automatic valve very nicely without any noise. So that I think long lines with valves on work very well in that way.

Mr. Crane: It is advisable to relieve the main at the extreme end with some automatic air valve; it is also better practice with the one pipe basement circuit to relieve the risers, with an automatic air valve at the top. It is also permissible with the overhead system of either water or steam, when the returns are brought back under-

neath the first floor, to take off of the return pipe with a tee, looking up, a nipple and an elbow, and treating it the same as you would the one pipe basement circuit radiators that might be located at other places that might not make it convenient to be reached by the riser itself. I only want to give this idea that any one who wishes to operate practically the one pipe system would know the limit to which they could go in this piping.

Mr. Barron: A good many will be deterred from using this system by the fact that a pitched L is required there and you have to have that tapped separately. It is not to be had in the general supply stores here in the East. The western concerns have it. In all our continuous main work, and we are doing both the drip and the continuous all the time, we use the ordinary L. The pitched L is a refinement and a good thing. In relation to the relative cost of the drip single pipe and the continuous main single pipe, I do not think there is any difference. The continuous main, I think, may cost a trifle more if you make the main the same size all the way round to the returns, as it should be made. I do not think that the cost of material and labor amounts to anything in the cost of the job. There are certain characters of building that the main goes into and it is certainly the most convenient way to plan piping, particularly if the boiler is located in the center of the building. Where the boiler is in the extreme end of the building, it is easier to plan with a return pipe, either overhead or on the floor. Of course, our eastern prejudice is in favor of putting it underneath the floor in the cement. Before we leave the subject I would like to trouble Mr. Jellett to go into the Philadelphia system of risers once again. He has done so several times. It is of supreme interest. I would like to know if Philadelphians have changed at all—if he still sticks to the orthodox return Philadelphia style, which is so different from the rest of the country.

Mr. S. A. Jellett: I do not think it would come in here, because it is a one-pipe discussion. And what Mr. Barron pleases to term the Philadelphia system is not a one-pipe system. In fact some of our western friends say it is a three-pipe system.

Mr. Barron: I would like Mr. Jellett to explain how he pipes small buildings, ordinary gravity Philadelphia work—ordinary store buildings.

Mr. Jellett: The ordinary store building is usually supplied with up feeds. It depends on the construction of the building. The one pipe system that Mr. Crane described as down-feed will answer for the supply in the usual Philadelphia practice on office buildings. That is the main exhaust pipe is carried to the attic, passing out

to the exhaust head and then coming off to allow for the expansion of the vertical line. From it the connections are taken out of the bottom of the mains all through the building. You have to run the exhaust to the atmosphere, and whether you distribute horizontally in the basement or in the attic it practically means nothing so far as piping is concerned. Now, the usual Philadelphia practice, as Mr. Barron pleases to term it, would be that branch lines leave the main at the highest point in the whole system. Every branch is separately valved in case of repairs in any line. Those valves are simply emergency valves. The lines will then come down through the building. The branches to the radiators themselves are pitched back from the valve to the main. The valves from the return are pitched toward the return, the practice in Philadelphia varying somewhat with different steam fitters, many using the check valve and no air valve on the radiator. Closing one valve closes and operates the radiator. In one or two cases I have used a special form of pop-check made to balance against very light pressures of steam.

Contrary to the usual practice that I find in other sections, we take from the return a line to our trap tank from the end of the descending feed main. Some western steam fitters who investigated it have described it as three pipe system. It has a down-feed into the radiators, a downward return, and then reliefs from the ends of all the risers. It has a complete circulation established within itself. You can shut off every radiator in the building and have complete circulation. The lines are all led back until they come to the traps, but back of the traps we will take a pipe from each line, join them together, into the relief pipe or air pipe as we call it, which is carried out to the atmosphere. The only exception to that rule is where we have to come down to the basement, run horizontally, and rise to a hall radiator, and there we have to use the air valve. But if we can get on a direct feed we can do away with the air valve. I have buildings thirteen stories high; I have one in mind that is 450 feet long and about 160 wide, and nine stories high, and it has 47,000 feet of radiating surface in it in different forms of cast iron radiators. The total number of radiators is about 704. Out of that number about twenty-six have air valves. They cannot be reached by a direct down-feed. We had to come off horizontally and then rise. There we added the air valve. But there are certainly 675 radiators in that building without any air valves.

Mr. Crane: The return line starts at the top radiator?

Mr. Jellett: Yes. If it is a ten-story building it will start at that floor. We will take a radiator that has a certain number of feet, say seventy square feet of surface. This main vertical line will

be figured—if there is a very large amount of surface it is generally figured at about 0.005 square inch of area for each square foot of radiating surface served. If it is a smaller installation it will be 0.006. We figure that at 0.012 of a square inch. You see that would give practically an area of a one inch pipe. That is practically the limiting line. I am talking now practically of the limitation between a one inch and an inch and a quarter feed. We have never used less than three-quarters of an inch; that is simply for convenience. A half inch pipe will drain most of them, but we find in office buildings, the breaking and bending of half inch pipes by men stepping on them and desks and furniture being put against them, and we have abandoned the half inch pipe on that account and use a three-quarter inch pipe. This feed line would be figured on 0.09. These rules must be used of course with the element of common sense proportionally to the extent of horizontal line you have got and the ramifications of your system. You get down to 0.03, as against 0.012 on the feed. On one or two large buildings on my horizontal returns I have got down to .001 and got good service. The amount of condensed water coming through a system of that kind continuously, of course is considerable, but if you take a system that has 40,000 feet of surface in it and then take 0.001 besides your main return, you are getting a pretty good sized pipe. But I find from examining pipes in different parts of the country that we use smaller returns in Philadelphia than is the common practice anywhere else. In a great many cases where these reliefs are not inserted the radiators are required to take the water out of the line. It may be that the radiators on the lower end of the lines are shut off. With a system such as that you have got a complete circulation irrespective of what is done in any individual room.

Mr. Barron: Upward and downward distribution was considered years ago by the Institution of Civil Engineers of Great Britain. The practice varies all over the world. I think this Philadelphia system is the best that has ever been devised. Of course, a great deal of this is more or less repetition, but it is a different aspect of the question and I think it is valuable.

Mr. Jellett: There are a number of one pipe systems. There is the straight one pipe, the one pipe relief and three or four applications of it. But I do not think there is anything very new in the steam piping. My experience has been, in traveling around, that there are only slight modifications in nearly all the large cities.

Mr. Rockwood: Just one correction. Mr. Jellett said that piping would not cost any differently in the two cases of single or double pipe systems. It seems plain to me that they would cost dif-

ferent amounts for the simple reason that the return pipe in one case is a water pipe and small, and in the other case it may be a six inch steam main, running nobody knows how far. Furthermore, where you supply the steam to the attic first you may have a comparatively small pipe, whereas if it is the main supply pipe it has got to be a good deal larger. It is evident Mr. Harvey and Mr. Crane would not agree as to which system was the better of the two which they respectively advocate. Now since Mr. Crane is of Cincinnati and Mr. Harvey of Detroit, it would give us a good deal of satisfaction and increase our knowledge of the relative cost of the two systems if they would each take an office building situated half way between Cincinnati and Detroit, and let us know what it would cost to pipe that building on the two different systems. What will it cost and how convenient and inconvenient are the two systems to use? Both systems would work all right if properly put up. If we are going to get comparative commercial results we must pursue our investigations in a scientific way, which requires us to apply the two systems to the same building.

Mr. Connolly: I think, Mr. Rockwood, that Mr. Crane said that there was a saving in piping of 5 per cent. on his overhead mains.

Mr. Jellett: A case that I had some time ago may be of interest. The specifications called for a one pipe system down-feed going to the attic and distributing and coming down. The building is thirteen stories high and very narrow. I wondered at getting specifications that way, because the owner of the building who had a great deal of work done previously had been a great advocate of the two pipe system. He had had a large experience in steam matters himself. I went to see him and asked, for curiosity, "Why did you have that laid out on the one pipe system?" He said: "This is an investment, and I want to save all the money I can." I said: "Do you think you are saving a great deal by having that?" He said: "Oh, yes." I said: "If you will give me a hundred dollars more I will take your contract on the two pipe system." He said: "Is that possible?" I said: "It would not apply in all cases, but in this particular building it would not make any difference."

Mr. Crane: Did you call this the two pipe system?

Mr. Jellett: In that particular building I called it the two pipe system. We went into the details carefully, and the actual material cost us less money. The labor cost us more. By the time we balanced it up on a job of $13,000 worth of piping there was less than a hundred dollars in the estimate between us. I have seen other cases where there would be a very decided difference. But

there is not the vast difference people think there is. The advantage of the one pipe system is in my mind more largely in the reduction of the number of pipes passing through the building, cutting up the floors. etc.

Mr. Barron: I would like to know the Philadelphia practice on the smaller work. We have heard the proportions on the larger work. I would like to know if he carries out the same proportions on gravity work. Of course he does not, but I would like to know what proportions he uses on gravity work.

Mr. Jellett: I may be able to give you some information, but I do comparatively little of what might be classed as "small work." The proportions of supply pipes to radiating surface served, which we use in making plans for piping of the different systems, are as follows: For house heating work, direct radiation, we would proportion the supply pipe 12-1,000 square inch of area to each square foot of radiating surface served. This would be for a system that would circulate without any indicated pressure on the gauge, and corresponds practically to exhaust heating, where I use the same rule. For indirect radiation, I increase the proportion to 15-1,000 square inch of area to each square foot of radiating surface served, as the condensation from indirect heating is greater than from direct.

In proportioning return pipes for gravity apparatus, I do not cut down my areas as fast as when proportioning a system that returns to a vent-tank. If you take, on a gravity apparatus, 12-1,000 square inch of area to one square foot of radiating surface served by the supply pipe, and proportion the returns to 9-1,000 square inch where they leave the radiators, it will work out to suit good practice on the usual gravity work. The main returns in basement into which the verticals discharge, can be still further reduced to say 6-1,000 square inch of area to one square foot of surface they are draining. Of course, with the gravity apparatus, I always use air valves on the radiators, but where the condensation is returned to a vented tank, and the radiators can be taken directly off the lines without forming air pockets, I usually dispense with the air valves.

President Mackay: If Mr. Harvey and Mr. Crane would co-operate in the way suggested, they might bring in a paper at the next meeting.

XLV.

ENGLISH PRACTICE IN THE WARMING AND VENTILATION OF TECHNICAL AND ART SCHOOLS.*

BY D. M. NESBITT, LONDON, ENG.
(Member of the Society.)

All will agree as to the positive necessity of thoroughly grappling with this question. It is not enough to have an inlet here and an outlet there and trust to natural ventilation. The authorities are now becoming alive to the fact that they can ask (and expect to obtain) that a definite temperature be maintained and that a certain volume of air shall be propelled into and out of the various rooms.

In the chemical department of science schools not only the vitiation of the air from the congregation of many people in one room, but also the noxious smells caused by the various experiments have to be taken care of.

The system which best fulfills the requirements is a mechanical one, and is a combination of the plenum and vacuum systems. The whole of the fresh air required for the building is preferably taken from four sides of an independent tower, so that whichever way the wind is blowing the effect of the wind shall be the same; also, air taken in at such a point is less liable to contamination. It is often difficult, however, to separate the air inlet from the main building; it may then be treated as an offset from a main wall, with openings in three sides, or again, a tower may be put up in connection with a lower part of the building and the air drawn down it. A very excellent air inlet was found in connection with an apparatus erected by Mr. Sylvester years ago at the Mickleover County Asylum, and which apparatus has since been turned into a mechanical system with very marked success. On the top of a tower, say 30 feet high, a cowl is fixed which moves round so that its mouth always faces the wind.

The fresh air on being drawn down the intake enters a large chamber, the sectional area of which should be at least three times greater

* This paper was prepared by Mr. Frank Ashwell, late partner of Mr. Nesbitt, by whom it has been revised and edited and supplemented with explanatory notes.

than the area of the inlet shaft. The object of thus opening out the space is to form a settling chamber for the particles of dust in the air, and also to obtain a large area of filtering material. Across this chamber the screen is fixed, which is formed of a rough open material, cocoa fiber, or jute. In connection with the screen a long brush is fixed which is balanced and fitted with two handles, so that it can be readily drawn up and down the filtering material. The use of this brush is two-fold; first, by drawing it up and down a few times the rust particles are brushed off the screen; second, the water is made to spread equally over all the filtering surface. Patents have recently been taken out for moving the brush very slowly up and down the screen by power, and also for very slowly revolving the filtering material, at the same time passing it through a bath of water, which, for some purposes, may be conveniently charged with a solution of disinfecting material. A supply of water is provided for the screen from an automatic flushing tank, which can be regulated to discharge its contents at stated periods as found necessary, according to the weather. In dry, dusty weather the screen is always kept damp. Easy access is arranged to both sides of the screen. Care is taken in arranging to take away the waste water that there is no connection with the drainage system. The fan is fixed on a wall parallel with the screen. It is thus equally fed with air and, as a consequence, run with less power and less vibration or noise. As to the mode of driving the fan, by far the greater number of fans are driven by gas engines, and they are no doubt economical and convenient, but they cannot be said to be the ideal means of driving fans for the plenum system for three reasons: First, irregular running; second, nuisance from smell, and third, noise.

The third is a serious difficulty, as, unless great care is taken, there is sure to be some noise. The fan is always driven on the delivery side, so that the pressure of air through the belt race will be into the gas engine room; whereas, if driven on the suction side, the smell would be drawn in by the fan.

In some technical schools a steam engine is required for experimental or other purposes and high pressure steam has to be carried on the boiler; in that case all the exhaust steam from the engines can be used in the winter time for warming the building. But the ideal driver for a fan is the electric motor, which is coming more and more into use; it is perfectly regular, under immediate control, the regulation of the speed being simple within certain and sufficient limits; perfectly noiseless, and free from smell, and though not so economical as the steam or gas engine is, for the small power required and advantages in other ways, an economical machine.

The question of electric lighting and the power for same in large institutions is very closely allied to the warming and ventilating question, as in cases where the light is generated on the spot the whole building may be warmed and supplied with hot water, with the exhaust from the engines. This is being most effectively done, especially for asylums and large kindred buildings.

Low pressure steam for buildings of such a size as technical schools has established its claim as the simplest and most economical means of getting the necessary heat. A boiler, or boilers, according to the size of the building, is fixed preferably six to eight feet below the level of the fan chamber. If it is possible to put the boiler down at the level above indicated a "gravity return" arrangement of pipes to the different batteries hereinafter mentioned may be secured. On this plan all the water of condensation from the batteries and pipes will automatically return to the boiler, and little or no waste of water will result. It is often impossible, owing to the nature of the ground, or position of drains, to put the boiler house down to so low a level as has been indicated; in that case a very efficient and reliable mode of returning the water of condensation may be used, viz., in the engine or motor room, two feet below the level of main trunk, is fixed an automatic return water pumping apparatus consisting of a steamtight vessel, called the "receiver," five feet long, two feet in diameter, to which is attached a small duplex pump. The return pipe from the heating system is connected to the top of the receiver; the pump draws the hot water from the receiver, forcing it into the boiler, so that no water whatever is wasted. Within the receiver is a float which is in communication with the steam supply to the pump. As the water rises or falls in the receiver the steam to the pump is turned on or off, the water in the receiver being thus automatically returned to the boiler. The pump can be operated either by steam from the boiler or by a belt from the power shaft.

From the delivery side of the fan a main trunk is formed in fair brickwork with struck joints, so as to catch as little dust as possible, the trunk being not less than six to six feet six inches high and, in width, proportionate to the amount of air to be passed. There are no projections to impede the current of air and all corners are rounded. It is preferable to arrange for the fan to deliver the air in a straight line under the building, or it is often convenient for the trunk to make a circuit around the building. Chambers formed in brickwork are taken off the main trunk to receive the heating surface, from which vertical flues ascend in the walls to the various rooms. These vertical flues are formed in the brickwork and are made as smooth

as possible. It is an admirable plan to build them in glazed brickwork so as to reduce friction to a minimum and prevent any possibility of dust accumulation, though the possibility of retaining any dust in a vertical flue is not great, yet too great care cannot be taken to keep everything in the plenum side of the apparatus clean and sweet, as it represents the lungs of the whole building. The trunk should also be lighted.

From a stop valve on the boiler a pipe is carried into the main trunk and run the whole length or circuit as the case may be, gradually getting smaller as the branches are taken off to the various batteries; the pipe is run at the highest level and arranged with fixed points for draining the condensed water into the return, and also, where necessary, provision is made to take up the expansion. The main return pipe is run in much the same way, gradually getting larger as it approaches the boiler and as branches come into it from the batteries. This pipe is run as close to the floor as convenient and is connected up to a non-return valve in the boiler or to a connection on the receiver before mentioned.

It will have been noticed that no warming of the air has been done up to this point except that which is due to the main steam and return pipes. All the warming is done in chambers directly under the vertical flues rising to the various rooms.

It may be well to point out here that the principle of this system is very different to that of warming the air at a central battery near the fan and blowing the air along small ducts at a high speed, or even of that where the air is moved at a slow speed in large trunks, but partially warmed at a central battery and extra warming and control of temperature done by small batteries at the base of the vertical flues. The nearer the heating surface can be placed to the space to be warmed the better and more economical results in coal consumption will accrue.

Owing to the necessity of having such large trunks to allow access for cleaning and inspection, and also to pass the necessary quantity of air at a slow speed, the cooling or condensing surface is very great, a strong point against warming the air before it enters the trunk; again, by having the main trunk as the cold air supply any particular room can be cooled in a few minutes and a simple mode of regulating the temperature of any room to the greatest nicety can be employed, as hereinafter explained, without in any way altering the volume of air supplied. Everyone is aware of the influence which the position of a room and state of the wind has upon its temperature; the plan of dividing the batteries of heating surface to take groups of rooms gives every opportunity for control of temperature

by air mixing, but, more than that, by arranging the batteries with steam valves only so much of the battery as is required to warm the rooms need be filled with steam, and thus fuel may be saved. The battery chamber in which the air is dealt with before it ascends the flues into the various rooms is formed in two chambers, hot and cold, divided by a concrete slab. In the upper part of this chamber the heating surface is fixed, made of hollow cast iron sections with gills cast on. These are bolted together in rows, arranged in such a way that they are readily disconnected and drawn out for cleaning. The several rows are connected together by an arrangement of a header valve, which gives steam to either two or three rows, according to the regulation required. The valve is arranged in such a way that only one connection with the main steam pipe is required at the front end, the water of condensation flowing into the return pipe through the same connection. This is an exceedingly simple and effective fitting and works admirably. An air valve is fixed on each row of sections. The bottom half of the chamber is the cold part. The vertical flues start out of the cold chamber and also have an opening from the hot air chamber. Across the flue at this level a shutter valve is fixed, which either shuts off the warm air, allowing cold air to pass up into the rooms, or shuts off the cold air, allowing all warmed air to pass up the flues. Intermediate positions of the shutter give a mixture of the warm and cold air. By means of this shutter, then, any grade of temperature, within certain limits, can be obtained in any particular room, independent of any other, and this by actuating the one shutter. It is advisable that a damper be fixed at the base of each flue to shut off the air from rooms not in use or to regulate the amount to the various rooms.

For cleaning or repairs access to the chambers can be obtained through doors which are provided. Where a school or building is large enough to require the constant attendance of a caretaker the regulation is put into his hands, telephone connection being made from the various departments to the engine or motor room, but where the school is a small one and the caretaker has other duties which take him away from the apparatus for long periods, the regulation of the shutter is effected from the rooms. It has been found from practical experience that the former plan is the most effective, and the best results are obtained from the apparatus. Where the question of expense is not one of grave consideration, thermometers fixed in the rooms, but registering the temperature in the main trunk are used very effectively.

Having fully considered the means of obtaining a supply of air and also the means of warming it and its regulation, the question

now comes as to its introduction to the various rooms. The air is introduced nine feet from the floor, with a maximum velocity of seven feet per second, five feet, however, being preferable. So far as is practicable the air is passed into the rooms on the warm side, the point of extraction being on the same wall at the floor level. In the case of a long room two inlets are used, one at each corner, with one outlet in the center. The same flue in different parts of its length is used for supply to one story and as a discharge from another above, the two parts being carefully separated. On no account is one flue section used to deilver air into two rooms, but in extreme cases the discharge flues are not so perfectly separated throughout their entire length. The discharge flues are arranged to extract from about the floor level as well as at the ceiling level. A shutter is provided at the ceiling opening which allows the discharge from the top or bottom of the room or partly from both, but in no case can the opening be shut. The apportioning of the flue areas to each room is based on the air supply required for the maximum number of occupants and their work. For reasons of policy, rather than to satisfy hygienic requirements, the amount of air per occupant is fixed at not less than 1,500 cubic feet per hour per occupant for lecture theaters, art school rooms, mechanics' shops, etc.; for chemical laboratories 3,000, and organic chemical laboratories, 4,000, if possible. The flue areas are computed for an air flow of from five to seven feet per second.

As far as possible it is considered advisable to conduct the extraction flues from the point where they terminate in the roof to a central tower of such a height that its action shall not be dominated by any other building. Care is taken that the sum of the areas of the outlet openings on two sides of the tower equals the area of the cross section of the shaft. In cases where it is not possible to get a high extraction tower, or where a considerable length of horizontal trunking is necessary in roof, back flaps of a light material are fixed so as to avoid all possibility of back draft by reason of temporary or excessive wind action, or the disturbance of the system's action by the stopping of the fan, opening of windows, etc.

On no account whatever is connection permitted between the extraction from the chemical department and the general extraction from the rest of the school. The great aim in designing the extraction from this department is to prevent the possibility of smell and fumes getting into the other departments of the school. The following plan has proved perfectly satisfactory. At a convenient position in the roof space a chamber of brick or wood, well tarred, is formed. A fan, say 24 to 30 inches in diameter, according to the amount of air and fumes to be extracted, is fixed with a vertical or horizontal shaft, as is most

convenient structurally, the air extracted by the fan being blown into the outer air through a dormer or tower. The fan is, as far as possible, constructed of copper and driven by an electric motor placed outside the chamber on the suction side. The means of starting and stopping the fan is operated from the room of the head of the chemical department. All extraction flues from the chemical department are carried into the fan chamber above mentioned. The areas of the openings from the chemical rooms are in excess of the areas of the inlet flues from the plenum system, so that by proportioning the flues this way, there will be a slight pull into the room when a door is opened, which would not be the case without the fan and if the extraction flues were of equal area. A good rule is to proportion the extraction flues through the draft closets and tables so that their combined area will equal the combined area of the inlet flues from the plenum, and to provide, besides, extraction flues in the walls whose combined area is equal to half the area of the inlet flues. Thus, in the event of some of the draft closets being closed, an increase of extraction area over inlet will still be maintained. In the chemical department it is wise to arrange for the ordinary extraction (as in the cases of other departments) for top and bottom extraction and, besides, fit each extraction opening with a shutter to regulate or wholly close it if desired. If one large extraction flue can be arranged to take the benches, draft closets, and deal with the ordinary ventilation as well, an excellent result is obtained, a direct opening into the flue from the top and bottom of a room being made, which should be fitted with a valve for regulation. As it is necessary to run flues from the tables, which are in the center of the room, the floor is made deep enough to take a main extraction trunk formed of glazed earthenware trough covered with glass into which the small flues from the tables and draft closets run at an angle in the direction of the air current; this main trunk may be graduated according to the number and size of flues taken into it. Its area, however, due to being horizontal is in excess of the sum of all the small flues. In some cases it is convenient, instead of running this main trunk under the floor and up the wall in one vertical flue, to divide it into two or more, one down each side of the room and running up the wall in two flues. These vertical flues are of earthenware, the square section used being more convenient for constructional purposes than a round one. The vertical flues on reaching the roof are carried into the fan chamber before mentioned, care being taken that the areas are not reduced at any point. The ordinary extraction from the room is taken up directly to the roof and connected to the fan chamber.

There are several arrangements for draft closets; those at the Medical School, Leeds Leigh Technical School, and the Rutherford College, Newcastle-on-Tyne, all being good. The arrangement at the Massachusetts Institute of Technology in Boston, however, commends itself as being admirable and to thoroughly meet all requirements. The following is a description of the arrangement by Professor Woodridge:—"Within the hood is an inclined diaphragm of such width and placing as to leave a slot three inches wide along the whole front of the hood. Its location and inclination serve to protect the hood contents from injury by the falling of debris from the flue. The hood sash is prevented by stops from being raised beyond a fixed point, such that its lower edge shall be, according to the height and temperature of the hood, from four to eight inches below the outer edge of the diaphragm. The space between the glass of the sash and the face of the hood is cut off from the hood space by raised sash, so preventing escape into the room of gases, etc., by that means. The use of the diaphragm is apparent in extending and equalizing the current along the entire length of the hood. The direction of inclination given to it and the front location of the slot may not, however, be so apparently reasonable. The aim in the latter arrangement is to concentrate the discharge current along the line of most natural escape of warmed gases from the hood into the room, since all gases to escape must pass this line, which would not be true of a similar slot at the rear of the hood. The inclination given to the diaphragm is slightly upward from rear to front, that the initial upward movement may not be completely and abruptly broken, so forming a deep stratum of fumes which might then escape at the lower part, because beyond the reach of the effective action of the discharge current, or else might cool and settle or be forced down along the rear walls at a point remote from the heating burner, and so escape."

The warming of entrance hall, corridors, and lavatories is done by direct radiation, fed by a steam main separate from the main which serves the batteries, as it is convenient and advisable when the school is not occupied to keep the place aired and free from freezing of the pipes in the lavatories.

In the case of board schools the question of warming and ventilating the assembly halls is one that needs special treatment and may be incidentally mentioned here. Owing to the large cubic space for the number of children, except when used for assembling, some direct radiation is placed in the room. In this way the room may be warmed without the aid of the fan and without displacing the large amount of cool air with warmed air from the plenum, a feature of

great convenience, it then being possible to warm the room for Sunday or other purposes, when it is inconvenient to run the plenum system. The radiators are supplied with air from the plenum, so that even when the fan is not running they draw in a fair quantity of air. When the fan is running sufficient air supply is allowed to give each child, say, 1000 cubic feet per hour.

For art schools there is sometimes furnished a conservatory that requires warming, which may be done by hot water circulation, the water being warmed in a heater, within which is a steam coil the flow and return pipes being taken from the heater in the usual way. As the conservatory usually requires some heat when the main heating apparatus is out of use and the boiler is not required for any other purpose than warming, it is convenient to put in a little separate gas heating boiler for the conservatory.

Having dealt with and described a typical system for warming and ventilating a technical and art school, a few words may be said as to the theory of the methods here adopted. This may especially be the case in view of the somewhat frequent challenging of the reasonableness of one of the methods, viz., the system of downward ventilation and the confusion of ideas, if not ignorance of the facts; which have in some instances marked the discussion of this part of the subject. Experience and careful observation have made clear the fact that the amount of air required in schools and other crowded rooms to keep the atmosphere reasonably pure must be determined by the number of persons to whom the air is supplied and that the maximum seating capacity must be the basis. This is the only sound scientific ground from which to start, for it will support all cases, from those in which a large gathering of people is the only source to be allowed for to one where the number of persons present bears only a small proportion to the special causes of impurity. Let us take, as an example, a class room 26 by 25 by 15 feet, holding 60 pupils. To calculate the amount of air required it is necessary to know how much air each pupil will vitiate and fix on a standard of purity. For all practical purposes the amount of CO_2 (carbon dioxide) is sufficient as a test of the purity or impurity of the air of a room, as the organic matter and micro-organisms in the ordinary case follow the amount of CO_2.

In a town, from which source the air supply for the school has to be obtained, the amount of CO_2 contained is four parts in 10,000. An adult in health emits six cubic feet of CO_2 per hour; this is equal to six parts in 10,000, making, with the four parts contained in the fresh air, 10 parts in 10,000. The question now comes as to how

much fresh air is required to dilute the above to bring it down to contain such an amount of CO_2, etc., as will make it healthy to breathe.

Dr. Parkes places the standard of purity at six parts in 10,000 4,000 cubic feet of air per occupant per hour being required to bring it to this standard. It is generally accepted, however, that if the standard of purity can be maintained at seven to eight parts of CO_2 in 10,000 a satisfactory result is obtained. To obtain this result about 2,000 cubic feet per occupant per hour must be allowed. The room above mentioned contains 10,000 cubic feet; therefore, taking the amount of air per occupant at $2{,}000 \times 60$, then 120,000 cu. ft. is the amount of fresh air required per hour to keep the room comparatively sweet; thus a total change of the air of the room is required 12 times in the hour. If only 30 students occupied the room the change would then be six times per hour, but in all cases the calculations should be made and the size of flues fixed for the largest number of occupants likely to use the room. The area of inlet and outlet flues to give the above results would require, allowing a velocity of air travel of six feet per second, just over six square feet for 60 students, and if for only 30 students, three square feet. Now the question to be solved is as to how this large amount of air is to be introduced and withdrawn without unpleasant drafts, so as to give the best diffusion, and this brings us to the question of the position of the air inlet and outlet. The movement of air through a room for the purposes of ventilation should be in one mass and of uniformity in direction and in velocity. If the incoming air can be given such movement the vitiation will keep increasing from the inlet to the outlet; the quantity of vitiated air in the room will be reduced to a minimum and also the time of its retention and the limit of space occupied by it.

In the case of the top entrance of the warm air at eight to nine feet high, the action fulfils all the points laid down in the last paragraph. The air in entering rises to the ceiling, diffusing as it approaches the cooler outside wall and window; it then begins to descend slowly and uniformly to the floor and is drawn off by the extraction flue at the floor level. Again, the warm air has by this means of introduction an oportunity of losing some of its heat by contact with the cooler walls and windows before it is inhaled, instead of being breathed at its highest temperature. Again, the warm fresh air admitted above the heads of the occupants is made to circulate throughout the room before it reaches the outlet; there is a constant movement and mixing of the air, a perfect diffusion, and the fresh warm air is brought to the face to be breathed before it sweeps the

body. It will thus be seen how important it is, if the best results are to be obtained, that the inlets and outlets should be properly located. In laying down a rule as to the positions of the inlet and outlet in technical schools, as in every other building, all the special conditions must be taken into account and these are cases, no doubt, where the inlet and outlet may require to be placed in positions other than those indicated. This especially applies in cases where gas is used and special vitiation other than that from the occupant takes place. Now that gas is being so universally displaced by electric light in technical schools, special provision for the vitiation from gas need hardly be considered.

The plenum system has many points of advantage when compared with others in which the heating surface is placed within the rooms to be warmed, and in which the fresh air is introduced directly into the rooms, or through the heating surface. They may be summarized as follows:

1. No heating surface in the rooms; therefore no useful space occupied.

2. With direct radiation, if sufficient heating surface for the coldest weather is fixed in the rooms, then in moderate weather the rooms are overheated, whereas with the plenum system at least three grades of temperature can be secured in the arrangement of the heating surface without any complication, besides which the air mixing is another means of control of the temperature.

3. No risk of freezing, which is a frequent cause of trouble with the ventilating or direct-indirect radiator, especially when hot water is used and the air supply has not been shut off during the night.

4. With a careful and intelligent attendant no more fuel is used than with an ordinary heating apparatus.

5. Owing to the air being introduced at one place and there cleansed, the amount of dust is found to be much less with buildings fitted with a plenum system. Experience in buildings where the system has been at work over three years points to the fact that less cleaning and painting is required than with other systems in which the air is introduced all over the building.

6. In summer it has been found that the rooms can be kept cooler with this system, due to the cool walls of the trunk reducing the temperature of the inflowing air.

7. All pipes and heating surface being fixed in the trunk no cutting about the building is necessary, and in case of repairs they can be readily got at without entering the rooms.

8. The question of first cost is undoubtedly a most important one and no discussion of the subject would be complete without the mat-

ter being mentioned. When comparing the cost of two different modes of warming and ventilating the same building great care must be taken to place the two schemes on the same basis as to the purity of air supplied, the quantity, the regularity, the convenience of working, etc. If this is not done the results obtained will be utterly useless and misleading; but whenever this is done and all the circumstances taken into account the extra cost of the plenum is a very moderate amount. As far as the actual apparatus is concerned, it has been found from estimating certain buildings that the plenum costs considerably less than a radiator scheme on the same basis with equally efficient extraction, but the extra cost of builders' work in forming trunks more than covers this. Surely, however, if it can be proved that the plenum system will do, and is doing, what is claimed for it, the small extra cost is not worthy of consideration. Hardly less important than the character of the instruction which our children and adults receive are the physical conditions under which that work should be done. It is quite unreasonable and unfair to expect the best work from our scholars in rooms in which the air is loaded with impurities, and it is even worse in the case of the teachers. The teachers have to spend their lives in the school rooms, the children only a few years. The head-master of one of the board schools in Leicester in which the plenum system is installed puts the matter very well. He says, in April, 1893: "For keeping the air pure and at a uniform temperature the plenum system of warming and ventilation is most effective. During the past 15 months—the period the school has been opened—the absences of teachers from illness have been reduced by one-half. All the teachers testify to the absence of headaches which they formerly felt under the old conditions." When using the term "old conditions" the head-master refers to former experience in schools that were not properly ventilated.

Concerning other methods of warming and ventilation, one of which it may be necessary to adopt where the plenum system cannot be installed, it must be clearly understood they should not be condemned; the great point to aim at is to adopt some definite system which, as far as structural and local considerations will allow, will fulfill the essential requirements.

The foregoing paper on "English Practice in the Warming and Ventilation of Technical and Art Schools" was prepared by my late partner, Mr. Frank Ashwell, of Leicester, but was never presented before any of the learned societies in this country, owing to Mr. Ashwell's sudden death last December (1896). I do not think Mr. Ashwell claimed anything very original in the paper, and to some of you who have given much study and thought to the subject of

warming and ventilation, it may appear a mere "Primer" to such a subject, but in England, where the literature and practical experience in *good* warming and ventilation is limited, I consider Mr. Ashwell has added much to the existing facts already known in a clear and concise manner, as is shown in this paper.

The paper covers much ground which has already been covered by others, but it is essential to state clear and unmistakable facts when it is borne in mind that is written for an English audience. I do not pretend to criticize the paper at any great length. I shall leave that for the members to do and will merely touch upon its salient points, and endeavor to explain our reasons and conclusions for adopting such practice in England. It must be remembered that we in this country have kept to the large air duct system, with low pressure for propelling the air into the buildings. We have tried the forced blast system in one or two asylum buildings, which answer very well, but preference leads me to the former practice where practicable. I mention this here, because the paper referred to is written entirely on the assumption of the low pressure system.

Air Filter.—An important feature in a well-equipped warming and ventilating installation is a filter for the removal of the impurities contained in the atmosphere of our large towns and cities. Several patents have been taken out for such devices, but to my mind there is still an open field for a good filter arrangement. The most recent one that has been tried in England is composed of "washed coke breeze," over which is passed a stream of water, either continuous or intermittent as desired. Although I have not tried one myself I have heard good accounts of this one. The filter referred to in the paper has been practically abandoned, owing to the cost of working and repairs.

Exhaust Steam.—The utilization of exhaust steam where combined plants are used has been very carefully considered during the past few years, and it is possible to show great economy from such a combination. It is seldom carried out in schools, as the conditions under which the schools work are very different to those in other buildings, but I have often used the exhaust steam from the electric light engines and warmed my large buildings, such as asylums, etc., with it, showing much economy in working.

Lighting of Trunks.—I quite agree with the author that the main air ducts should, whenever practicable, be lighted, and, by preference, with electricity.

Air Supply.—The amount of air which the author gives, 1,000 cubic feet per child per hour, will, no doubt, not meet with the approval of many members, but it must not be forgotten that in Eng-

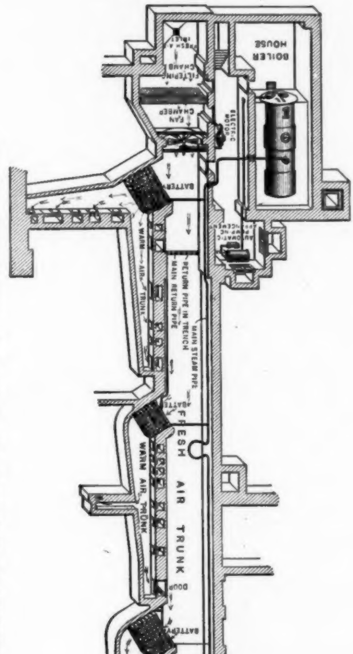


FIG. 1.—ISOMETRICAL PLAN VIEW OF BASEMENT OF LEICESTER TECHNICAL SCHOOL, SHOWING POSITIONS OF BOILER, PUMP, FAN, BATTERIES, FLUES, ETC.

land we are only beginning to "feel our way" in warming and ventilation, and I trust that when the question becomes more popular and better understood in the British Isles we shall also be able to give our pupils 30 cubic feet of air per minute, as in Massachusetts and other parts of the States, or even more. But cost plays an important part in good warming and ventilation, and when you speak to an architect as requiring an inlet flue 24 by 14 inches (for a class room

TESTS AT LEICESTER TECHNICAL SCHOOL.

	Velocity in Feet Per Second.	Velocity in Feet Per Minute.	Feet of Air Entering Room Per Hour.	Change Per Hour.	Change of Air as Arranged on Plans.	Air Supply Per Student Per Hour.
Lower Ground Floor:						
Room 16	8.5	510.	82.620	5 6	6.	
" 15	7.5	450.	78.300	7.2	7.	
" 14	5.5	330.	25.740	4.6	5.	
" 13	8.5	510.	39.780	5.2	5 or 6	
" 12	8 5	510.	39.780	5.2	5 or 6	
" 11	7.5	450.	35.100	6.4	6.	
" 10	6.5	390.	67.860	6.2	6.	
" 9	9.	540.	32.400	5.6	5 or 6	
Ground Floor:						
Room 2	6.	360.	21.600	6.6	7.2	
" 3	7.5	450.	78.300	7.	7.	Number of students not determined.
" 4	8.	480.	37.440	6.8	7.	
Mr. Went's Room....	..	....	....	...	4.	
Library....	8.5	510.	27.540	4.	4.	
Room 5	6.	360.	28.080	5.	4.	
" 6	6.	360.	62.640	5.	5.	
" 7	3.2	390.	76.050	7.8	7.6	
" 8	20.	1200.	43.200	8.	7.6	
First Floor:						
Room T	6.	360.	64.800	7.6	7.6	
	6.	360.	64.800			
" S	8.	480.	36.000	3.2	3.6	
" R	..	....	....	...	...	
" Q	11.5	690.	41.400	4.2	4.1	
	11.5	690.	41.400			
" P	..	..	....	...	..	
" O	10.	600.	36.000	3.1	3.1	
" N	7.	420.	25.200	2.6	2.6	
" M	8.	480.	17.280	3.	3.	
Second Floor:						
Room I	8.	480.	23.040	2.4	2 8	
" H	7.	420.	31.500	3.2	3.3	
" G	8.5	510.	38 250	3.	3.3	
" F	9.	540.	19.440	3.	3.3	
" E	9.	540.	32.400	3.4	2.4	
		540.	32.400			
" C.O	10.25	600.	28.800	3.	3.3	
			28.800			
	8.5	510.	38.250	4.	3.5	
Art Library	9.	540.	19.440	3.	3.2	

for 60 children) and a similar one for exhaust purposes, he gets positively alarmed and begins to tell the poor warming and ventilating engineer that that will never do, as he will not be able to get the school built under the "limit," viz., £10 per head, or $50. Again, we have to contend with the automatic warming and ventilating engineer, who simply sticks an outlet (so-called "air pump") of some hideous design on the apex of the roof and thinks the job complete; the principle is "so simple" and "so very cheap" that many archi-

tects gladly adopt this plan, so that they may be allowed a greater sum for ornamentation, or some kind of "bauble" to be fixed on the main façade, so that future generations who may be educated at this wonderful "haven of education" may bless him—forsooth, most likely the rising generation will censure him for spending the public funds in such a ruthless fashion and omitting the most essential feature of the school building, viz., its *lungs.*

CIRCUIT PIPE.—The "circuit pipe" is much used in installations. It is simple to erect, works noiselessly and with no trouble whatever. It is necessary, however, to have the pipes of large diameter. The author of the paper deserves, I think, all the credit that can be given to his memory for the persistent advocacy of the plenum system. No man strived harder than he to obtain a good firm footing for the plenum system in England, and to-day we can see success written in large letters over his name in this particular line. He was too modest to take credit for much of his work, and left it to others to do the "shouting," but one of the finest memorials that can ever be raised to his memory is the installation of the plenum system at the Nottingham Borough Asylum, nearly 12 years ago. There have been installations carried out before this one in England, I know, but never has a system been carried out on such lines as this one, and it is the envy of all medical superintendents who inspect it. Working, as I did, with the late Mr. Ashwell for close on 13 years, I can say that whatever he took in hand to do himself he did conscientiously and well.

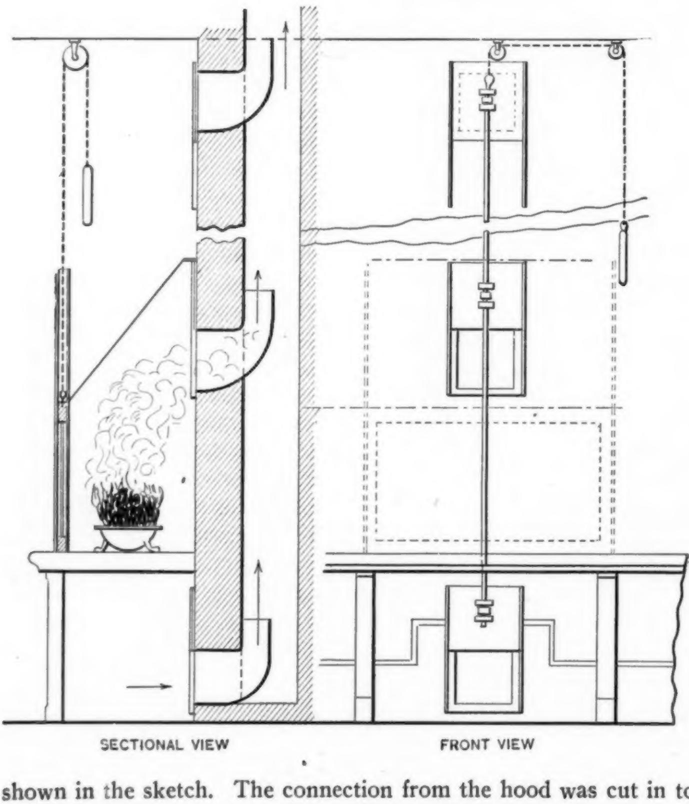
I again have pleasure in making my acquaintance through this paper with many dear old American friends, to all of whom I tender every good wish and Godspeed.

Since the foregoing paper was prepared, I have made some tests at the Leicester Technical School, a copy of which, showing the results obtained, is given on the previous page. In Fig. 1 is presented an isometrical drawing of the basement of this school, showing the position of the boiler, batteries, flues, etc.

DISCUSSION.

Mr. Jellett: I was especially interested in the description Mr. Nesbitt gives of the extraction of air from the hoods in the chemical laboratory, as it is one of the most difficult things to do that I know of. I found, with even long flues of what seemed to be sufficient area, that the results have been, considering the way you would ventilate an ordinary room, very unsatisfactory. There is one way of ventilating hoods that has proven to be the most satis-

factory of any that I know. (See sketch.) The fumes are generated under the hood, and the men are working in front of it. One place I have in mind will have a class of 300 men in at one time. The room itself is not of sufficient area to properly accommodate this number. Added to that, the fumes from the hoods make the air very impure and difficult to breathe. We have a lot of flues in the walls that we had to make use of. We carried them to the floor, as



SECTIONAL VIEW FRONT VIEW

shown in the sketch. The connection from the hood was cut in to ventilate it and the registers for the top of the room were above, slightly below the ceiling. Now, if the three are opened at once we do not get the results we want. That has been overcome by means of a gate and three dampers sliding vertically and connected by a rod, as shown. The sum of the areas of two openings into the flue equals the full carrying capacity of the flue, and with the arrangement applied under each hood any number of hoods can be

cut out of service without affecting the general ventilation of the room, or any number can be thrown in. I think this is a good application of an old arrangement.

Mr. Wolfe: Regarding the question of ventilating the laboratory, I appreciate Mr. Jellett's remarks. It has been the practice with us to carry the hood pretty well down, and then at the opening we carry the ventilation through a pipe to the flue. In a place where we get gas we put in a sufficient number of gas burners to double the velocity in the chamber as against the velocity of the ventilation of the room. Consequently we do not have any trouble with gases coming out, because it is a stronger draft than the draft drawing the other way. Over the hoods we put a little extra heat to draw the air out, rather than have it travel across the room. That is more simple, and seems to answer every requirement and the results are good.

Mr. Barron: I hope to hear Mr. Nesbitt's paper discussed fully. I would like to hear Prof. Carpenter's views on this particular style of ventilation for schools and colleges, something in which he is particularly interested.

Prof. Carpenter: I am very much pleased with this paper, since it gives in a very general way the practice in England. It advances no specially new idea, nor does it advance any theory for us to combat, and it seems to me it is a perfectly sound paper and what it says is applicable, as far as it goes, to our work here. I think, however, that with our extreme conditions other arrangements would perhaps answer better than those described here, at least those which are given preference here. He mentions a very great number of ways, and perhaps nearly all the practical ways, of heating and ventilating with pressure and with ordinary light, or what he calls a very light pressure—ordinary atmospheric pressure. It strikes me that my preference would be for the plenum system or the forced blast system, on account of the extreme changes of temperature that we have here. I tnink it is better adapted to our climate than the system described in the paper, or at least the system for which he states he has a preference in the paper; but that is, perhaps, of very little importance.

So far as ventilating laboratories is concerned, we have had some experience in that line, and as we have had to add our system to old building or buildings already built there has been considerable difficulty in getting perfect ventilation. In fact, our ventilation in the chemical laboratories is anything but perfect at the present time, although it is very much better than existed previously. The system in use is a natural

system of ventilation supplemented by exhaust fans, and it has proven, if not a very high order of ventilation, at least satisfactory. In regard to the heating and ventilation of our institution, which is largely a technical school, I might say that conditions seem to be very different from those which are supposed to exist in the technical schools described here. In nearly all the colleges in this country the students simply occupy the college buildings during the time of recitations. The recitations are usually from forty minutes to one hour in length. The rooms are very seldom used more than three hours consecutively; frequently used only one hour each day. Another thing, too, the rooms are very seldom crowded. In fact, a room of this size is frequently occupied only by 15 or 20 or 30 persons. That is what you might say is pretty nearly the average condition in colleges as they exist, and hence, for those conditions the question of ventilation is not of vital importance, as it is in connection with the lecture rooms and school buildings and with the class of schools which are described in the paper. In regard to lecture rooms, such, for instance, as exist in the law schools, there are different conditions. In that case we have very crowded rooms, and I would say that in connection with our law school the ventilation is very poor indeed, and our students who are to be our future lawgivers suffer the most from lack of ventilation of any class of students that we have. They have indirect heating in their building and natural ventilation, and a chance for cleaning the room between each lecture, but the room gets very bad indeed. Aside from that, I think the ventilation conditions as they exist in our institutions are fairly good. All the new buildings which we have put in within the last four or five years are supplied with a plenum system of heating and ventilation something similar to that described in my paper. In our library building we have a system of indirect heating supplemented by a plenum system for ventilation. That is, we run a large ventilating fan during the entire time the library is occupied, and in that way introduce plenty of fresh air and take it out. In the older recitation buildings, which, as I say, are used only for small classes and only a few hours in a day, we have simply systems of direct heating, and there has been no complaint on the score of ventilation, simply for the reasons mentioned —very few people occupy the rooms. Now, that represents in a nutshell the character of the ventilation in Cornell University, and I think it is also pretty fairly representative of the ventilation in most of the colleges in this country which have been running for a number of years. I think also that in nearly all the new buildings which have been put up in all the colleges during the last few years the

system of forced ventilation has been installed, so that in that respect we have quite different conditions from those which in this paper are supposed to exist.

Mr. Kent: I would like to know if it is the sense of the members that this statement on page 6 is the ideal system for the conditions in this country, that is, that "the air is passed into the warm rooms on the warm side, the point of extraction being on the same wall at the the floor level." It seems to me that in a long room, when it is very cold out of doors, the heat would not distribute quite as nicely as the author describes, but that there would be great currents of cold air sweeping down on the cold side of the room, and it would be advisable to have the entrance of warm air on the cold side of the room, or else have a radiator under the window.

Mr. Jellett: I am familiar with the condition in the buildings of the University of Pennsylvania, having had to do with, I think, some nine out of the group. In the old buildings the air is introduced through the old system of flues on the inner walls, or is taken out on the inner walls; but the greater exposure due to the large rooms is taken care of by direct radiation controlled by thermostats. The delivery of air is constant in all parts of the building. When the temperature reaches the point at which the thermostat is set, the direct radiation only is cut off and the air supply is always maintained. That has been applied to the college building, the medical department and the dental department. In the dental department is also situated the dissecting room, and that department has a number of benches of indirect radiators, with a supply of air which is made constant during the night. The ventilation changes in the dissecting room are eight and ten an hour at all times, and that is not any too many. But it has been the common practice in all buildings of that kind to bring the air in and out on the same side. If you get into the chapel of the University of Pennsylvania, which is some 75 feet, of course it is impracticable; but the air there is brought in from the inner wall and from the side walls, and the subsequent heating is done by the direct radiators on the outer walls located beneath the windows. The chapel or main lecture hall of the building is used possibly twenty minutes in the morning. There is no use for it again until the next day. We have thermostats, all controlled by one operating arm at the door. As the class is dismissed the switch is thrown and the steam cut off, and it is only thrown on by the attendant the next morning some time before the assembling of the college classes. That was done with the idea of economy of steam, as the space to be warmed was 120,000 cubic feet, and as they had this short period of occupancy, it

was thought advisable to save the steam. That same application has been made in the lecture pits of the medical department. There the thermostats have been set to control the temperature at 64 degrees. We originally set them at 68, and gradually worked them down to 64. We found that the number of men occupying the pit will promptly bring the temperature up to 69 and 70. It has been set permanently at that point. But the newer buildings are heated, keeping in view their use. The museum of anatomy is entirely direct radiation. It was figured at a temperature not to exceed sixty, as many of the specimens are wax models, and as the building is not occupied by classes—it is simply for inspection. The hospital is direct-indirect. The laboratory of hygiene has probably five different systems. It is a school of hygiene, and one of the things they talk of is heating and ventilation, and the system was put in to show the different methods, and was put up in such a way that the students can take it apart and experiment on all the parts of it, weigh the condensation, test temperatures, etc. The chemical laboratory in the building has nine different forms of radiators that are boxed and cased, arrangements made for filtering screens of cotton and for other experiments, and each radiator has a number of fittings on the intake and out-take for occasionally reading from the thermometers and gauges and measuring and weighing the condensation, and also as to the volume of air that a given number of square feet will deliver at a certain temperature. That building also has in the lecture room a fan system. The amount of surface in the building is far in excess of the amount required to heat it, because at times they experiment as to the maximum delivery of air that can be obtained from any sized area, and it requires more heat than is necessary to warm the room to get that delivery. We found that the movement of air through sheets of raw cotton was a difficult thing to do. There is no mechanical means of forcing air with the exception of electrical means. All the connections to the chemical laboratory are drawn down in direct pipes, which passes under the floor in the basement to the exhaust blower, and are then discharged through a direct end, the pipe being carried some distance from the building before it has its vent. Then the dental building is a combination of the fan and direct radiation. The hospital buildings are indirect radiation supplemented with fans. They are old buildings. The newer buildings are entirely on the fan system, with supplementary coils of indirect radiators. The library is indirect radiation, the space being very large, indeed, in proportion to the number of occupants. The ceiling in the main hall is some fifty feet high. That gives you a fair idea of the vari-

ous buildings of the institution. The newer ones are up to date in most of their details. The older ones have made the application to suit the conditions as they exist to get the best possible results, and they are in general giving very satisfactory results.

Mr. Kent: I understood Mr. Jellett to say that in their plenum system they keep a constant air supply. Does that refer to only the time the students are in there?

Mr. Jellett: It is during the hours of use of the college, from eight in the morning until five, because a number of the class stay over in the laboratories for special experimental work. At night it is shut off and the direct radiation is used.

Mr. Barron: If Mr. Meyer has no objection, I would like to hear more of his views in regard to this paper. Before doing that I would say that I met Mr. Nesbitt here some years ago, when he came to read a paper before the Master Steam Fitters' Association. He is not at all thin-skinned, and he is not averse to having his paper criticized in any way.

Mr. Meyer: Mr. Barron calls upon me, but I really do not think I am competent to criticize the paper in any way; but I thank him for his invitation.

Mr. Connolly: I would move that Mr. Barron criticize. He is asking for criticism, and he is a first-class critic himself. We may all criticize it after hearing from him—or criticize him.

Mr. Barron: In that spirit I will do so, Mr. President. Of course, that was what I was aiming at. (Laughter.) We all want to be courteous to foreigners, particularly to our British cousins. But I can assure you in regard to Mr. Nesbitt that it is uncalled for—he is one of ourselves; he came to this counttry and inspected everything, and the paper that he wrote on the Nottingham Asylum was one of the best illustrated papers that ever was read before any engineering society. He is not a forced blast man, nor is he a slow velocity disc propeller fanatic at all. That is a preference due to the peculiar conditions there. Really, as heating and ventilation have advanced in the world to-day, this is out of date—such a system as is described here. You could not get what Mr. Kent called this morning the commercial aspect of this question. That is, Englishmen do not thoroughly appreciate the commercial point of engineering. I heard Prof. Carpenter explain that some years ago. It is the interest on plant; it is the cost. Mr. Nesbitt speaks of the bauble that the architect puts on a building. Now, from the architect's standpoint a man who says that is a Philistine. The architect does that as an artist and as a very superior person, and your criticism he regards as the poor reasoning of a utilitarian, and he re-

gards that as far more important than the pure air which you pretend to give him. I think Mr. Nesbitt could have designed a plant to effect everything that he effects here for half the money, that is, by using direct radiation combined with a forced blast system of high velocity. The English engineers will always prefer this slow speed propeller disc fan until there is some other form that will require less power. They will always prefer these brick ducts, because it takes it out of their bill of costs in their estimate. I am sure that is the only practical way to look at that question. It is simply a question between the engineer and the architect. The commercial factor, as Mr. Kent can explain to you, enters into all our American engineering, and when we criticize the man who does not consider the interest on the plant, the money invested, what efforts we have to make to get the money for the investment, we forget in our criticism the main feature of our engineering.

XLVI.

HEATING AND VENTILATING CHURCH AND PARISH BUILDINGS BY FORCED DRAFT.

BY B. H. CARPENTER, WILKES BARRE, PA.

(Member of the Society.)

In designing and carrying out this system it was necessary, in order to insure its success, to obtain the following results: First, to heat the buildings by the gravity system at all times; second, to heat and ventilate the buildings when necessary by mechanical means; third, to avoid drafts of any nature; fourth, to prevent objectionable noises. Under the first head there were several features to contend with. The basement was but six feet in height, and in order to get the proper elevation between the steam coils and the water line in the boilers, it was necessary to excavate to a depth of six feet and set the boilers on the concrete 12 feet below the joists. By using coils four and a half feet high I was enabled to get 22 inches between the water line of the boilers and the bottom of the coils.

The chimney was located at one end of the building, while the fresh air inlet was at the other end of the building, a distance of about 80 feet away. This would necessitate either a long smoke pipe, a long fresh air duct, or a long steam pipe. The last mentioned was thought most feasible and the apparatus was so planned, with boilers near the chimney and the heater near the fresh air inlet, enlarging the steam and return pipes, in proportion to distance, to overcome friction.

The boilers used were of the cast iron sectional type, two in number, each having 13 sections. Each section was rated at 270 square feet capacity, making a total capacity of 7,000 square feet. A 24-inch smoke pipe of No. 12 iron connected the boilers to the chimney, which was lined with 24-inch square terra cotta flue lining. The piping from the boilers was run as shown on the accompanying plan, Fig. 1 and was so arranged with valves that either or both boilers could be put in service.

The heater, composed of 5,000 feet of heating surface, was divided into six equal divisions, each part being valved at feed and return

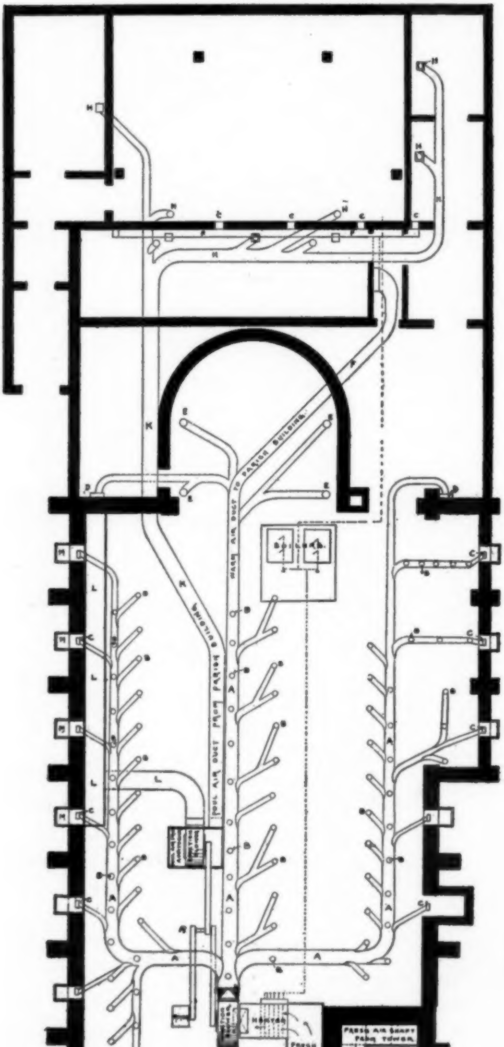


FIG. I.

and supplied with an automatic float air valve. Above the heater and at one side was placed a register P, Fig. 2, connected to the heater by a wooden register box lined with asbestos, to convey the heated air to the room above when the fan is not running. This box

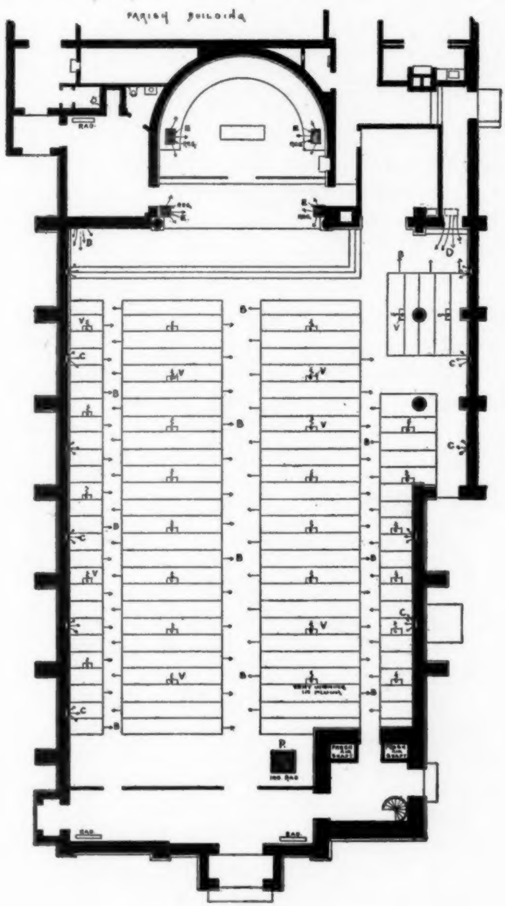


FIG. 2.

has a tight slide or valve with which to cut off when the fans are running.

The vestibule and vestry are both heated by direct radiation. In the vestibule are two radiators, each having 100 square feet of heating surface. The parish building in the rear of the church proper is not

a new building. It was formerly heated by direct and indirect radiation, with an attempt at ventilation, which was a failure, though the heating was successful. This building was supplied with a wrought iron steam generator, which I abandoned, connecting the piping system, after some minor changes, to the new boilers. The radiation was not disturbed. The piping above ground in the basements is all protected by asbestos sectional covering. The pipes underground are encased in wooden boxes.

Our second point was to ventilate when necessary. To do this two three-quarter housing steel plate pulley fans were installed, the induction fan being 110 inches diameter and the eduction fan 100 inches. The induction fan draws the air down from the flues in the tower, as shown in Figs. 1 and 2, where it enters the tower at a height of 80 feet from the ground. The air then passes over the

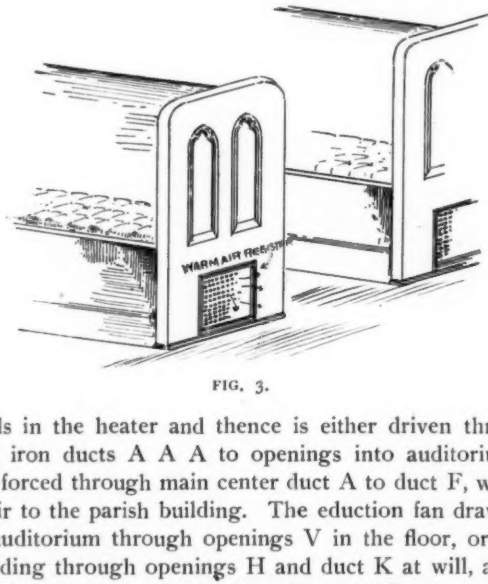


FIG. 3.

heated coils in the heater and thence is either driven through the galvanized iron ducts A A A to openings into auditorium, or, if desired, is forced through main center duct A to duct F, which conveys the air to the parish building. The eduction fan draws the air from the auditorium through openings V in the floor, or from the parish building through openings H and duct K at will, and drives it through duct L to openings in the side wall M, whence the air is thrown outside the building.

The warm fresh air passes into the auditorium through 87 8-inch ducts B to openings in pew ends; also through 11 5 by 12 inch flues C leading to 10 by 12 inch registers in side walls; also through two 8 by 24 inch flues D leading to 20 by 24 inch registers in end wall and four 20 by 24 inch registers E in chancel. The air, by passing through pew ends at a velocity of five feet per second,

through wall flue C at 8¼ feet per second, through flues D at 8¼ feet per second, and through floor registers E at 6½ feet per second, furnishes a total of 20,300 cubic feet per minute to the auditorium, which gives 1,000 persons (the seating capacity of the auditorium) 20 cubic feet each every minute, a sufficient volume, at its maximum speed, to change the whole body of air in the auditorium every 12½ minutes.

It was the purpose of the system to heat, but not to ventilate the church and parish building at the same time. Valves were provided where necessary to cut the air off from auditorium and force it through duct F to the parish building. When the air is being forced into the parish building, the valve in the duct K is opened and the door O closed, and the air is drawn from the parish building and forced outside. The parish building was furnished with fresh air through duct F, thence through rising duct and through four registers C located 16 feet above the floor. The air is drawn down through eight floor registers H into the duct K and carried back to the eduction fan. The ducts are proportioned according to the amount of air passing through them necessary to ventilate the various rooms.

In order to avoid drafts in the auditorium the air was brought into the room, as well as expelled from the room, through the large number of openings, and by having the pipes of sufficient size the air was driven at a slow speed. The openings C in the auditorium are placed under the windows to counteract the currents of cold air falling from the windows.

The fourth point was to prevent objectionable noises. The fans are driven by a 12½ horse power electric motor of the four pole type, running at a speed of 900 revolutions per minute. The motor drives a countershaft R which is belted to the two fans. A resistance coil is placed in connection with the motor in order that its speed can be varied at will to suit the requirements. The fans, the motor, and the countershaft are all bolted to planks, these being bolted to brick and concrete foundations. To prevent the carrying of vibration from fans to ducts all connections between them are made with canvas and asbestos cloth.

The openings D and E in the chancel end of the auditorium are of good size and evenly distributed in order that the large volumes of air which are introduced through them may convey more clearly the sounds of the human voice and the tones of the organ to the congregation. By the use of the mechanical system the buildings can not only be heated in winter, but may also be cooled and ventilated in summer, the air being drawn down through the tower and coming

in contact with the thousands of feet of cold piping before entering the auditorium.

Up to the time of going to press with this paper the system, as far as tested, has proved to be mechanically correct. Pea, or No. 6, coal is used in the boilers, and the buildings are well heated. At the opening of the church, on Christmas day, with the outside temperature at ten degrees above zero at 7 o'clock in the morning, the air in the auditorium was kept at 68 degrees with but two of the steam coils turned on, the circulation of air being very good.

DISCUSSION.

Mr. Carpenter: I might say here that the sexton is a very good one and took an interest in the system, and was anxious that it should be a success, and I rather think he had more coils turned on before nine o'clock. But at nine o'clock when the temperature was taken there were but two coils turned on. There were not at any rate more than four.

Mr. Rockwood: I would like to ask Mr. Carpenter if he has made a test to find out, under cold conditions out of doors, how long it takes to heat the church building up from cold.

Mr. Carpenter: No. There was no test of the kind made, because the organ was placed in position only the week before Christmas, and the heating system had been running constantly for at least two weeks, and the tuner required for the purpose of tuning his organ that the church be maintained at a certain temperature day and night while he was tuning it, so that after the time of the completion of the plant there was no time given to make any such test.

Mr. Connolly: I would like to ask Mr. Carpenter a few question in regard to the parish building. I notice he has a warm air duct to the building, and also a foul air duct, and he speaks in one part of the paper about direct radiation. Now, in what way does he divide the parish building? That is, does he heat by direct and indirect just on Sunday or whenever there are services in the church, or does he have the entire parish building heated by indirect when the church system is going, and when it is closed off, does he heat by indirect radiation? I do not think the paper touches that point quite clearly. I would like to see it amplified.

Mr. Carpenter: The parish building was heated originally by direct and indirect radiation, the attempt at ventilation being to exhaust air through a flue which ran near the smoke flue from the boiler. This was a failure and had been disconnected some time before, so that the building was warmed without the use of the fan

from the church. There was direct and indirect sufficient in the parish building to heat it at all times, and when the building was in use the purpose was to force the tempered air from the fan in the church into the parish building. The fan system is in under the church building, and the fans are used for the church when there are services in the church, and they are used for the parish building when there is service in the parish building, and at no other time. The radiation from the direct radiation and the radiation passing over the coil are sufficient to keep the church warm without any ventilation.

Mr. Barron: If the belt were cut connected with the eduction blower, what difference would it make in the running of the apparatus or in the ventilating or heating of the building? In other words, if you threw that out of doors, what difference would that make in the plant so far as other results were concerned?

Mr. Carpenter: Taking a large building as this is, we thought it necessary to take the air around from a great many openings, and in doing that assist one blower by having the second blower on. If you had plenty of power on the first blower, it would probably do the work about the same way. But it overcomes friction, I think, to a certain extent, and equalizes it a little better by having the second blower.

Mr. Barron: I do not think there is any particular objection to it, only I think it is a good thing for pulling the air through the window, and if you do not have it there, the air would go out through the window, which would be a little better, in my opinion. I think it is an expense that could possibly be avoided. I do not know how it could.

Mr. Carpenter: For the purpose of counteracting any such drafts we use a 110 inch fan to drive the air in, and a 100 inch fan to take the air out. That was the idea in making them of different sizes, so that there would be a small pressure in the building at all times.

Mr. Hyde: I should take it that if all the power that it required to run those two fans was exerted on the one, either on the exhaust or on the supply, the result would be just the same as now; that in view of the fact that one is inducing an outflow relieves the other of the necessity of furnishing the power to force it out, and the same condition of things would be brought about by one fan; that the building is actually under pressure, but being relieved in a different manner from what it would be if it was forced. One fan now runs with just half the power it would take to run that fan if the other fan was in there.

Mr. Barwick: From the ground floor it seems to me that Mr. Carpenter is right in using an additional fan, for if the plan is cor-

rect it does not appear that there is any other method of driving the air out unless it is driven out through the side windows.

Mr. Jellett: It is a great mistake to attempt to ventilate a church building entirely by exhausting. The constant opening of doors during the services gives strong indrafts of cold air. Apart from that, the average stained glass windows are very leaky, and if you create a vacuum in the building you have indrafts of cold air. I have had a good deal to do with a great many church buildings. I have in hand now plans of one of the more recent churches in Philadelphia with a wall 82 feet in height. The walls are entirely of dressed stone from floor to ceiling—no inside plaster. The windows are all fixed; that is, there is no window in the building that can be opened. The building has no pews. It is built on the cathedral plan. It has removable chairs, and it is open at all times to the public from eight or nine in the morning until evening, so that the building must be reasonably tempered at all times. It presented a rather different problem from most churches. While services are only held in the church on Sundays, the week-day service being held in the chapel that adjoins, at the same time the keeping of the building open to the public made it necessary that the building should be reasonably tempered. The heating is all done at the outer walls. The floors are of English colored cements carried out in ornamental designs, the floors being on brick arches on which this cement finish is put. The air is brought in close to the floor from the sides. It could not be brought in from above without interfering with the architectural features of the building. The velocity is kept down very low. At the base of each of the flues is a bench of indirect radiators. It is designed to warm the building to 60 degrees from a temperature of 10 above zero. The air delivered from the mouth of the fan is passed through a bench of indirect radiators. If the weather is cold the temperature is increased by the steam on the indirects. The air is drawn out of the church from the line of registers in the floor on the center, and is carried to the exhaust fan. There is a third fan which delivers air into the parish building and into the chapel, and that fan is also connected into the ventilating duct from the church in such a manner that they can defer warming the church until shortly before the time when the congregation arrives, when the power of both fans can be put on that building for half an hour or an hour. Then the exhaust fan is cut off from the work and the system proceeds in the usual manner. We have made a test of the building to determine the lengh of time required to warm the room, and I made tests in other classes of buildings, and it has been my experience that a heating system that is em-

ployed to do this work in continuous operation will not gain over six degrees per hour in temperature on the building. That is, assume the building at 40; there has been no heat on for some hours. The average gain on such a building with a system that is ample for the work when it is used continuously will not exceed six degrees per hour. The most I have ever gotten has been seven degrees per hour, and that with double sash windows. I made an experiment on a building that was also allowed to stand cold from Saturday to Monday morning. The temperature outside was 16, and the wind blowing at the time; it took us from seven o'clock in the morning until half past one to get the temperature to 70. The building was very much exposed, but after once getting it to 70 there was not the slightest trouble to maintain it, and there never has been any trouble at any time to maintain it. There is a mistaken idea, I think, of a great many people, that a system of heating should be capable of warming a cold building of large area in an hour or two. A building that is shut from Sunday night until the following Sunday morning is a cold building. Its walls are cold and it will absorb a great deal of heat. If you figured to start the heating system at nine o'clock and have the church at 70 degrees at half-past ten you will be badly caught on it, unless your system is far in excess of its needs for its average work.

Mr. B. H. Carpenter: In connection with the question of two fans, I would say that the original idea was to heat and ventilate the church building only, and at that time we had designed it with the one fan, but the Board of Trustees afterward decided to ventilate the parish building, and then we added the second fan, as it would be almost impossible to ventilate it without, from the location of the building, the location of the rooms.

Mr. Rockwood: I think this is a cleverly designed apparatus, and I have no criticisms to pass upon it, but I do not think it would be a well-considered apparatus for a very large church. My experience with church buildings is that they are rarely not warm enough. The warming part of it is rather overdone than underdone, but the ventilation is another story. It is very rare that the ventilation of a church building at the end of the service is what it should be. I have cogitated over the subject a good deal, and my deductions are not exactly in line with the prevailing idea that ventilation should be considered simply as a question of dilution of the air in the church. I do not think my ideas are novel, but still they are contrary to the accepted idea. Mr. Nesbitt in his paper made a statement which I think is true, and which relates to what I have to say: "The movement of air through a room for the purposes of

ventilation should be in one mass, and of uniformity in direction and in velocity." Now, would not that method of removal of the impure air be a better method to follow in designing your apparatus than the method of diluting the air? Dilution means sweeping a large volume of air across the heads of several people. It seems to me that if the air were introduced at the bottom of the church in some suitable way, through a great number of openings, in such a manner that instantly upon issuing from the opening it came in contact with the body and head of each individual, and after passing that person should immediately ascend and escape through an orifice in the room, that would be the ideal system; it would be the system which would prove to be the most economical if it could be positive when in operation. In other words, as we only really need 62 feet of air an hour and we allow 30 a minute by the dilution theory, it seems as though that was a great extravagance, and we should get along with nearer to the actual amount required. Such an arrangement could be, it seems to me, provided if the air were admitted at a temperature twenty or thirty degrees lower than that of the body, at the floor of the church, allowed to ascend by the pressure which the fan would exert upon the incoming air, and by the ascensional power which it would gather by coming in contact with the warm body of the individual, and this air should not be relied upon to impart the heat or radiation in the building to the outer work. That should be done by means of direct radiation arranged in any convenient manner around the walls of the building, and therein I should think would lie the difficulty one would encounter in trying to carry the system into practice. I can see that too much window surface and too much relative space between radiators might thoroughly upset your arrangements in the matter of requiring air to ascend vertically from the floor. But perhaps if you had the right amount of radiation to counteract the downward draft at the window and if you took the air in beneath the pews about a foot and a half from the floor in such a manner that it would come in at a very low velocity (too low to be noticed by putting your hand at the orifice) and should come in in front of each person, if enough air was supplied through enough openings so that the air could not have cross currents, and only one way of escape, and that overhead, was allowed, it seems to me that such a system would afford the ideal ventilation in such buildings.

Mr. Wolfe: If I am in order, I would like to make one reference to what Mr. Rockwood has said. If modern ventilation, so far as we know, is not a question of so diluting the impure air as to make it practically pure, what is it?

Mr. Jellett: There is one point on church heating that has probably caused more trouble than any other that I would like to see a way of getting over. I have never found that a fan system, even with a pretty fair pressure on the building, would overcome it, without the arrangement I show (making sketch). In the average Gothic building there are usually pretty large windows in the clerestory in the nave, the columns going down here and there. Now, it is inadvisable to bring in any pressure of air on the floor on account of the movement of people up and down the aisles; it is very objectionable. The fresh air is brought in here. Now, there is a movement of air up there in that direction, and it is met by the chilling power here, and very frequently starts a down draft right there. I have had more complaints from people sitting here of drafts on their heads than from any other one single thing. The last building I had that objection in was a large Episcopal church in which the width was very great and the height here was some seventy- two feet. The exposure of these upper windows was very great. They were of stained glass and very leaky. At this point in the decoration there was a broad band of one color. Below it there was sort of a plaster cornice. I took two rows of steam pipes horizontally right there from end to end of the church, brought up my pipe to the rear and passed along that line, then back and down, with valves in the basement. I never had a complaint afterwards of a draft. I counteracted the falling effect of that column. The pipes themselves were painted the same color as the decorated band, and are never noticed. In face there are very few points at which you can get a view of them. But it has met the objection, and it is a point I think worth considering.

Mr. Connolly: We have here this afternoon Mr. R. M. Gettis, consulting engineer of the School Board of Newark, New Jersey. I would like to hear a few words from him on ventilation. I move that the privilege of the floor be extended to Mr. Gettis for a few remarks.

The President: I do not think it is necessary to make a motion, but I would be glad to put it.

The motion was put and carried.

Mr. Gettis: Mr. Chairman and Gentlemen of the Association: I came here this afternoon as a listener to see what your association was doing, without thinking at all that I would be asked to say anything to the association. I want to say that I have been very much interested in the discussions pro and con that have been going on. In relation to the paper immediately under discussion, I will say that I have visited the church that Mr. Carpenter has described in his

paper a few days after it was opened. I attended service there, and I might give my opinion as to why he used two fans instead of one, and that is this—that the construction of that church was hardly such that an engineer would attempt to use a single fan in it. If you are going to ventilate a building you must have some means of getting your air out of the building, and the construction of that church was such that a single fan in the building would hardly amount to much in the line of ventilation. It would force the air into the church and warm it, but as far as ventilation was concerned, I hardly think that they could have done it otherwise. I think from what I saw of the plant just through one service, that they have a plant that will bring about very good results, and will do credit to their work. I am myself a believer in the two-fan method. Perhaps that is one of the reasons why I think that in this particular instance it was hardly a reasonable line of engineering to attempt anything else, and I believe my experience has proven to me that we can get better results with two fans than we can with one. I know it is urged that you are forming a vacuum in your building, but a fan can be easily arranged so that your exhaust is not equal to your supply. You still have the advantage of movement, and you have then a movement of air exhausting from your room that is always permanent, or rather is always of the same order, and you can absolutely control it. While if you have your exhaust from the inlet or what is known as the gravity, why it seems to me hardly possible to control it to as high a degree as with an eduction fan. I want to thank you for your courtesy and to assure you that I am much interested in your discussions.

Mr. Meyer: I would like to ask the gentleman if the use of two fans is not due to the fact that you get a greater difference of pressure, the same as running two dynamos, perhaps, in series. Suppose Mr. Carpenter had shut down his exhaust fan and he ran the other fan and induced a certain amount of air. Of course as the air came in it would have to go out, but he could not get that same current of air through, because where he has two fans he has two pulling in series and he has a greater difference in pressure to cause that motion of the air. Is not that the reason why two are better than one?

Mr. Gettis: My belief is simply this: If you are throwing the air into a room with a single fan—take for instance if you have a duct method known as the gravity or the natural way by duct—then you have a partial control of the currents in getting them out. That control is dependent upon the natural laws, supplemented if you put artificial heat in your ducts. Now, I hold that with a second fan you absolutely control the currents going in, and as a

result you can get a more even distribution of your exhaust and get a better result than you can by the single fan. I have made a number of tests in this line of work in a number of buildings, and we have a double fan plant arranged so that it may be run by a gravity exhaust, and by speeding up my supply fan I can get far better results, but not equal to the results that I can get by keeping my supply fan down to a lower speed, throwing air into the room at a low velocity and absolutely controlling the currents that are going out by the eduction fans.

Mr. Wolfe: If I am in order, there is one question in regard to ventilation by mechanical means that I would like to speak of. I think the best possible method is two fans, because an adjustment can be made that will absolutely insure your distribution of air, and the adjustment once made, with the fan system or mechanical method, so to speak, you have your building right. But the great advantage of the fan is that it will deliver so much air, and we have a given quantity to work from regardless of the wind pressure from any direction, and the exhaust fan adjusted to act in unison with the supply fan enables an engineer to very accurately adjust his work, so that no matter from which way the wind blows or what the temperature is he is certain of his air supply.

XLVII.

TOPICAL DISCUSSIONS.

TOPIC NO. I.

"The rating of heating coils for hot blast heating."

Mr. William Kent: For the purpose of opening this discussion I will make some remarks to show how limited is the extent of our acquaintance with the subject. The question is, the rating of heating coils for hot blast heating. If we could get a standard rate of transmission of heat through the metal of the coil we might say that a heating coil will transmit so many heat units per square foot per hour per degree of the average difference of temperature between the steam and the mean temperature of the air entering and passing out. We might then be able to construct a formula on which any steam coil could be designed and rated; say so many square feet of heating surface should be rated as being equivalent to the heating of so many cubic feet of air through a stated difference of temperature. The fact is, however, that there are so many variables and so many unknown quantities that no one has yet been able to devise a satisfactory formula or rule for designing coils. Imagine a large steam coil inside of a box and the cold air entering and hot air escaping—what different variables have we to consider? We have the heating surface itself; its thickness may possibly enter as a factor. The question whether that heating surface is a plain heating surface or some other form; the question whether the pipes are horizontal or vertical may have something to do with the problem, and whether the insides are clean or greasy. So much for the variables of the problem which depend on the heating surface. Then we have to consider the arrangement of the heating pipes in the box; shall we make the box long and narrow and low, or shall we make it short, wide and high? What form shall we give it, a cubical form or a long trough form, and how shall we arrange the exit and entrance? The question of entrance and exit, I think, will be found experimentally to be an extremely

important one. We will not know much about the effect of different sizes and shapes until we make some tests. Cold air may try to take the shortest path across. As it gets heated it will tend to rise. The conflicting currents will make eddies, making some of the surface ineffective. I know of no experiments that have been made on the subject, but I will suggest how an experiment might be made to show the effects of short-circuiting of the currents and eddies. Have a coil in a box fitted with movable baffle plates and thermometers at, say, a dozen different points. If we can so arrange the baffle plates as to cause a uniform gradation of heat throughout the whole box we will have the maximum efficiency of the arrangement, but if the thermometers show an irregular distribution of the temperature we may be sure some portion of the coil is less efficient than it should be. It will also make a great deal of difference whether we have the coils themselves so arranged as to prevent entrapping of air. The rate of transmission of heat, and therefore the rating of the coil, will also depend on the temperature of entrance and the temperature of exit, and when we have a great difference of temperature, such as taking in air at zero or near zero and turning it out at 150 degrees, that range of temperature will probably give us a different formula than where we take it in at 60 and heat it up to 90. I make these remarks to show how exceedingly complex this problem is, and we will not be able to get any accurate data on it till a series of experiments has been carried out to determine the influence of these different variables.

Mr. B. H. Carpenter: With regard to the air seeking the easiest entrance, as Mr. Kent has pointed out, it seems to me that the question of arranging the inlet and outlet will depend on the size of openings between the pipes. In the discussion Mr. Jellett said that most heater coils were too close together. I think the air opening should be the full size of the heater toward the fan.

Mr. Barron: A valuable feature, I think, is in calling attention to the grease in the heaters. Exhaust steam soon fouls the pipes. If that interferes with the efficiency of a heater to the same eextent that it does with that of a surface condenser it is a valuable thing to know, and to take into consideration whether there should not be some means of cleaning the inside of the hot blast coils.

Mr. Meyer: I should like to ask Mr. Kent how he proposes to protect those thermometers from direct radiation. I had occasion to make tests of that character, and I found a great deal of difficulty in doing that very thing.

Mr. Kent: It would be a difficult thing—one of the complexities of the problem.

TOPIC NO. 2.

It is admitted by every one that it is economical to use exhaust steam for heating purposes if such use does not cause back pressure at the engine. Question: "Under what conditions is it also economical to use exhaust steam if such does not create back pressure?"

Mr. George I. Rockwood: The idea prevails somewhat widely among mechanical engineers that conditions cannot exist under which it would be economical to exhaust a back-pressure into a heating system; or, to turn the statement about, anything done to reduce the back-pressure on an engine exhausting into a heating system will effect a saving in fuel. I wish to try and put in a clear light the limits to the correctness of this view.

In the first place, it will be obvious to all that in those plants where the engines working under a back-pressure do not exhaust more steam than the heating system will condense, no advantage would be gained by reducing the back-pressure, regardless of how great that pressure may be. In other words, if there is a use for all the steam that an engine may exhaust at a certain pressure, the only loss of heat from the steam during its passage through the engine is the heat equivalent to the work done, which amount is no wise affected by the presence or absence of back-pressure. The effect of reducing the back-pressure on the engine would be to reduce the quantity of steam exhausted by it, which reduction would have to be made good by drawing some steam directly from the boiler into the heating system.

If the engine were larger than need be to supply enough steam for condensation in the radiators, which is the same thing as having the back-pressure too high, so that the engine would take more steam per stroke to do its work than would be sufficient for heating purposes, it is clear that a reduction of the back-pressure would cause a saving, unless the radiators had too little surface to heat the rooms properly with a lower pressure of the steam, or unless the circulation was thereby affected. But both of these contingencies could be easily be looked out against in a house-heating system.

There are frequent cases, however, where the back-pressure cannot be reduced, and the question is whether it is best to use exhaust steam under such circumstances, when it cannot all be condensed. Take a problem which often presents itself to the mill engineer: "Cans," or driers, must have steam supplied them at a pressure of not less than six pounds above the atmosphere. Will it pay to carry a back-pressure on the engine for the purpose of supplying these ma-

chines with exhaust steam? The answer cannot be told until it is known how much steam the cans and driers need and how much steam the engine exhausts, both under normal conditions and with the back-pressure of six pounds.

If the weight of steam exhausted at 6 pounds back-pressure is just the weight needed in the driers, then manifestly it is best to carry the back-pressure and use the exhaust steam, because by so doing but little more than one-half as much steam need be made by the boilers as if both engine and driers took live steam. How much more than one-half would depend on the size and kind of engine in use. If a throttling governor engine, small for the power it produced, were the one in question, then the saving would be almost exactly 50 per cent., because the back-pressure would be so insignificant a part of the whole mean effective pressure; and as such engines are generally the kind employed to run calico printing machines, driers, etc., it is fair to say that if the boiler pressure be raised ten pounds and the exhaust steam be used for heating under a back-pressure of six pounds, the saving over heating with live steam would be exactly 50 per cent. Hence, it would be economy to carry the back-pressure on such engines, unless they exhaust (at six pounds back-pressure) almost twice the weight of steam which the driers will take.

The case is not so favorable where the engine is of the automatic cut-off or compound condensing variety. A compound engine has so many expansions that its mean effective pressure, referred to the low-pressure cylinder, is very low; and a back-pressure of six pounds, even with a non-condensing compound engine, would increase the steam consumption from 30 per cent. to 40 per cent. If the heating system requires all and more than this extra 30 per cent. to 40 per cent. of steam, then obviously there would be no net loss, but rather a gain by carrying the back-pressure. Mr. William Kent has stated the rule to be observed as follows: It pays to use back-pressure at the engine if the quantity of steam required by the driers, etc., is greater than the increased consumption thereby made necessary in the engine. This is a very simple rule, which the discussion shows to be true, but it ought to silence those engineers who harp continually on the folly of permitting back-pressure on an engine. It may, or, on the other hand, it may not, be economical to carry back-pressure. Each case must be decided by applying Mr. Kent's rule:

1. Estimate the quantity of steam used for power *before* applying back-pressure.

2. Estimate the quantity of steam necessary for power *after* applying back-pressure.

3. Estimate the quantity of steam used in the heating apparatus at that back-pressure.

Rule: If the excess quantity of steam caused by applying back-pressure to the engine is less than the quantity used in the heating apparatus, there is a saving; and the amount of steam saved is equal to the difference between the increase at the engine and the condensation in the heating apparatus.

TOPIC NO. 3.

"Does the present day competition promote good engineering?"

Mr Rockwood: Here is a good illustration of the advantage of making topics conform to good English in their wording This is a preposterous question to ask this Society, as it is worded, because we are supposed to consider nothing about engineering except heating and ventilating engineering. Let us introduce that into the question and discuss it on those lines, because I think that there is no question that modern engineering has been greatly benefited by competition, taking it at large. I take it that the question is whether that has been the case in heating and ventilating engineering.

The President: I believe that the gentleman who proposed the question intended that it should apply to heating and ventilation.

Mr. Kent: It seems to me that this question of competition and engineering embodies two subjects that are not necessarily related to each other. An engineer may be called in to design a plant and then he may come in to inspect it. A manufacturer may have engineers in his employ who tell him how to design his particular apparatus and how to manufacture it, and how to do it cheaply. Other engineeers are employed by the architect, say one of them to prepare the plan and another to inspect the work, or the same man may plan the work and inspect it afterwards. What has that to do with competition? All that competition has to do is to fix the price between different bidders, and that has not anything to do with engineering. In that respect competition has nothing to do with getting good engineering. In another sense competition does promote good engineering. Competition tends to lower the price of things of first class quality, and when things of good quality are cheapened, then the purchaser is going to buy more of them. If you have $10,000 to build a house, you are going to build a good deal better house if materials are cheap than if they are all dear, so that

in that respect, tending to lower the price of good materials tends to promote good engineering, because the man who pays for good engineering buys better things, because they are not too high-priced.

Mr. Barron: This question shows the evil of having literary men in engineering societies. This question is philosophical, scientific, economic. Get the professors of economics from Yale and Columbia, and you would have a very fine fight, particularly if one was a philosophical individualist and the other a philosophical collectivist. The philosophical collectivist would say that competition was an evil, and the individualist would show that all the blessings we have are due to it.

Mr. Wolfe: On Topic No. 3, Dr. Billings wrote long ago that good ventilating and low prices would not go together or did not go together. Now, we who are contractors know that we may draw very elaborate plans which we are thoroughly satisfied in our own minds will do the work. Unfortunately, the owner who knows nothing, or comparatively nothing, of the science of warming and ventilation —and it certainly is a science—is not a capable judge, and the most ignorant man can make an argument to him which carries as much weight as the argument of the best engineer in the country, simply because he cannot comprehend the good or the bad points of either side. The man who will put in the cheapest possible plant will make the strongest possible argument, and it is about all there is to that.

Mr. Blackmore: It seems to me that one of the evils we ought to fight against is one I have no doubt the engineer and contractor meet continually; that is, they are met with an appropriation of $2,000 or $2,500 to heat and ventilate a building when they know it would take $4,000 or $5,000 to do the work properly. If you can get heating apparatus in there for the amount appropriated it will go through; if you cannot, it won't. That is one of the most discouraging features of our profession to-day. I do not doubt that every one of us has met that and meets it continually, and it seems impossible to get owners to realize that the heating and ventilation are among the first requisites of a building. The architect is the first man consulted in regard to a building, and he wants to get the best-looking building and the greatest amount of room for the money that he is told by the committee he will have to keep his building within, and he gets all his part done and then he finds he has very little left for the heating and ventilating or possibly plumbing and drainage. He goes around to see who will possibly give him what

he wants—the heating and ventilating and possibly the sanitary arrangements—for the amount he has got left, and he will generally find somebody who will do it. While this is not much of an argument, I thought it wise to bring up the point that we ought to struggle and fight against just that feeling that exists in the architectural profession, and very largely and more particularly amongst school committees appointed to look after the building of a new school or a new building in any community. The last thing they look at as a rule is heating and ventilation, and if they do look after it, it is in such a way as to get it done as cheaply as possible.

TOPIC NO. 8.

"Do the results obtained from the use of thermostats justify the cost of their installation?"

Mr. Connolly: I think Prof. Carpenter's paper read last night struck the nail on the head by stating that they were very reliable, and from my experience I would judge that they do justify the cost of installation. I do not think the subject needs very much discussion.

Mr. Barron: Mr. Connolly's statement disposes of the question in a very short way. I think there are a number here who have had experience with thermostats. I am sure that the thermostat is coming, and is bound to be used and is all right. All you have to say to this question is, Yes, they do justify it. Yet every man knows that he goes into buildings where the thermostats have been put in and they are thrown out. It is simply as we advance a little further the thermostat is inevitable. It will be in all work of that characer. That is there will be an automatic heating device on every plant that pretends to be at all complete.

TOPIC NO. 9.

"Is there a simple and direct method of determining the extent of vitiation of air?"

President Mackay: Possibly I can save a little time by stating that the instrument used by the Massachusetts State Inspectors for determining the purity of air in school buildings is what is known as the Wolpert air tester. In consists of a common test tube with a line drawn at a point to fit the rest of the apparatus and standing upon a standard the base of which has a small black mark. The tube is filled with water to the point indicated upon the tube. Then there is a plunger that is made to fit exactly into this tube. At the

other end there is a rubber tube. I mistook myself when I said water. I mean a saturated solution of lime water. Don't go to the drug store to buy lime water that you don't know anything about, because it won't work. Be sure that it is fresh within two weeks, and that it is a thoroughly saturated solution. They use filtering paper and filter the water, and put enough lime in the water to get a complete solution of saturated lime water. The graduation on the glass is supposed to hold the amount of lime water, as against the amount of air held in the rubber tube at the end of the plunger. Accompanying the apparatus is a table and directions for use. You simply squeeze the bulb, and letting go, you take air from the room. You put that in slowly, press the bulb until the air is expelled from it and has passed through that lime water. When the lime water is precipitated and becomes milky to the extent that you cannot see that black mark on the base you read your table that I referred to and each number of fillings will show the quantity of CO_2 in 10,000 parts in the general atmosphere. That, if used with ordinary care, is within five per cent. of the ten-thousandth part of the atmosphere; it has been so proven there by the Board. That simply indicates the amount of carbonic dioxide in the air, and that is taken as a factor as to showing other impurities which almost invariably accompany the carbonic dioxide in impure air. That is the only simple instrument I know. It can be bought for about two dollars, or for a dollar and a half.

Mr. Crane: Will you give the address of the party who makes that?

The President: I cannot tell it you at this moment, but I think you can get it down at Meyrowitz's on Twenty-third street; or, failing there, at Keuffel & Esser's on Fulton street. Is there any further discussion on the question?

TOPIC NO. 10.

"What size reducing valve is required to deliver the steam to fill a 10 inch pipe at one pound pressure, the steam being reduced from eight pounds to one pound?"

Mr. Paul: I handed the question in, but it is not my question. I was in Chicago last week and one of the members of this society desired me to ask the question. He was situated in this way: His contract required that on a certain building he had in hand, one pound pressure should be delivered to him. When he came to get the work in he found that while there was one pound pressure on

one side of the valve it was impossible to receive but half a pound pressure on the other side. I tried to get him to make his question a little more definite, but he said that was just the question he wanted to ask—what sized hole should be through the valve in order to accomplish the result.

Mr. Barron: How long a 10 inch pipe and what is the radiation of it? The question is very indefinite. As to reducing valves, the usual form of putting on reducing valves is to put on a ten inch valve and then a by-pass around it. I regard that as all wrong. There should be a 10 inch gate valve and the by-pass should be put on with a 3 inch or 2 inch or $1\frac{1}{2}$ reducing valve. The 10 inch reducing valve is a cumbersome affair, more likely to get out of order than the smaller valve. It is uselessly complicating the apparatus without any gain whatever. I believe generally, where this is specified, it is one of those peculiar things that a man specified the larger valve because it is more expensive and it looks right—it looks as if the valve should be the full size of the pipe. I think the other is better. If you submit that to an architect he thinks right away it is an attempt to save. I think the smaller reducing valve is better.

Mr. Jellett: I have never used larger than a 4 inch reducing valve on any piece of work I ever did. I have had some 54,000 feet of surface, but I have not had eight pounds on the other side; I have had it 100. In most cases where reducing valves of that kind are used high pressure is used. I have in mind some installations where there is approximately 60,000 feet in use four to six years. In one case the main heating pipe was 18 inches and the reducing valve was 4 inches, and it has never failed to serve with one pound initial pressure on the right side of the valve.

Mr. Barron: Don't you know that all our specifications generally specify the large valve? Don't you have to put this large valve in, although your judgment tells you it is not the proper thing? It is really a grievance we have to contend with. It is a purely engineering grievance, in that you have got to do a thing that is wrong because it looks right, because it looks honest.

Mr. Paul: We have constructed our valve with a very small supply opening and a very large discharge, allowing for the expansion of the steam in passing through the valve. If we put in a small valve our experience was this: We put in a 3 inch valve to supply a certain given amount of surface; beyond the valve a 3 inch pipe ran about 20 feet, and went into a 4 inch main. We were unable to supply that building with heat when the engine shut down unless we went and opened the reducing valve. Then when the engine started up the valve would not shut off. The consequence was that

we continued throwing steam to the atmosphere. We took that valve out and put in a 2 inch valve with a 4 inch discharge, and we could shut the engine off at any time and the building would be taken care of. We could turn the engine on at any time and there would be no steam go to the atmosphere.

XLVIII.

SEMI-ANNUAL MEETING.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

ATLANTIC CITY, N. J., July 15, 1898.

The following members and visitors were registered as being present:

Frank K. Chew, New York; A. H. Fowler, Philadelphia, Pa.; J. A. Goodrich, New York; John Gormly, Philadelphia, Pa.; Henry B. Gombers, New York; Andrew Harvey, Detroit, Mich.; William H. Hill, New York; S. A. Jellett, Philadelphia, Pa.; H. A. Joslin, New York; John Leitch, New York; H. C. Meyers, Jr., New York; W. M. Mackay, New York; William McMannis, New York; T. C. Northcott, Elmira, N. Y.; H. A. Smith, New York; J. M. Stoughton, New York; George P. Steel, Philadelphia, Pa.; T. J. Waters, Chicago, Ill.; W. F. Wolfe, Boston, Mass.; Warren Webster, Camden, N. J.; Timothy Kieley, New York; Theodore Webster, Camden, N. J.

After roll call the President addressed the meeting as follows:

The President: Gentlemen of the Society, and Guests.—I am very glad to see those that are here. It shows the interest that is being taken in our society. I understand that later in the day our attendance will be much larger. This being the semi-annual meeting, and hardly an official meeting, but more of a social one, there is no formal business to be transacted that I know of. I hope you will concur with me in the idea that we should attend to business strictly and in order, so that our programme may be completed and our time not wasted. I should like to have you determine, when the questions for discussion come up, whether the limit shall be five minutes or ten minutes for each speaker, and I hope that you will not think I am over-stepping my duty if I hold the speakers strictly to the question under discussion.

I do not think there is anything to be referred to in an official way,

except regarding our financial standing, which will be explained to you by Mr. Jellett.

Secretary Jellett: Gentlemen, the one short-coming of the past six months has been the failure of members to pay their dues promptly. That has retarded the work of the society very much. At the beginning of the year, when your new officers were installed, it was found that instead of there being a balance in the treasury of $327 there was a deficit of between $600 and $700. We had the $327 in the treasury, but we had bills to be met of $986. So that your Board of Managers had quite a problem to face. Those bills were for the printing of last year's proceedings, which were not issued until the first of January this year; also the rent of the hall in which we held our meeting in January; the stenographer's bill for services at the annual meeting, and two or three small bills for printing programmes and other work. Since that time we have been trying to wipe out the indebtedness. That has prevented us from going on with some new things which, in the opinion of your Board of Managers, it is for the interest of this society to enter upon. The indebtedness has been cleared off with the exception of about $100. There is due from members in the neighborhood of $1,100. If each member paid his dues in full we would be approximately $1,000 to the good. Many members have paid this year's dues, $10, but some are behind two and three years, and the Board of Managers have given the latter a notice, which terminates to-day, that their names will be dropped from the roll unless their dues are paid. Replies have been received from some of these men which state their position and show that they are so situated at present that they cannot pay, and we do not want to shut them out; there are many, however, who are behind simply through carelessness. Your Board of Managers have given a great deal of time and attention to the affairs of the society, and they fear that the work of the society will be greatly hampered for want of money to do the necessary work.

The President: Gentlemen, it might be well to consider now how long each speaker shall be entitled to the floor in the discussion.

On motion of Mr. Gormly, as amended by Mr. Northcott, it was resolved:

That each speaker be allowed ten minutes in the discussion of each topic before the society, and that if it is deemed necessary the time may be further extended by a vote of the meeting; provided, that if a speaker occupies less than ten minutes in the discussion of any question he shall have to his credit the balance of the time if he wishes to speak again.

The President: The first paper to be presented is one by Mr. T. C. Northcott, entitled,

"Some Accepted Tests on Ventilation—are They Reliable?"

The paper was read by Mr. Northcott and was followed by a discussion. Topic No. 1, "The Use of Draft Regulators," was then discussed. This was followed by a discussion on Topic No. 3, "Boiler Furnaces for Steam Power Installations."

After these discussions the Secretary made some remarks concerning letters received from some five or six members who expected to be present at the meeting, but who were detained from one cause and another.

Mr. McMannis: I wish to say to the members of the society who are present that Mr. Kieley extends an invitation to a carriage ride this afternoon. If all who will accept the invitation will notify me to that effect I will inform Mr. Kieley, and he will make the necessary arrangements.

The President: Gentlemen, you have heard the invitation extended on behalf of Mr. Kieley. What is your pleasure in regard to it?

Secretary Jellett: I think it better to accept the invitation individually, and not as a society. We discussed a similar question to this once, and, inasmuch as the society is not a trade organization, the Board of Managers decided that we could not properly accept invitations of this kind. I think the society as a society should not put itself in a position to accept these invitations. The society was organized with the idea of leaving out all trade questions, and I think we ought to stick to that. Personally, it would afford me a great deal of pleasure as an individual to accept Mr. Kieley's invitation, and I shall be glad to do so, but not as an officer of the society. I move that we extend our thanks to Mr. Kieley for his kind invitation. Then it will be left to the individuals, if they like, to accept it. (Seconded and carried.)

The meeting then took a recess until 8 P. M.

EVENING SESSION.

The President: Gentlemen, pursuant to a resolution passed at the last annual meeting the Chair was directed to appoint a committee consisting of a member from each city of 50,000 inhabitants or more, to report at our next annual meeting as to the form of ventilation in use in schools. I have the honor to announce the following as the committee:

A. E. Kenrick, E. Glantsberg, B. F. Stangland, W. M. Mackay,

T. C. Northcott, Andrew Harvey, John Gormly, B. H. Carpenter, G. I. Rockwood, Henry Adams, J. A. Langdon, H. D. Crane, Prof. J. H. Kinealy, Charles F. Tay, D. M. Nesbitt, A. B. Reck, D. M. Quay.

The President: The Secretary will now announce the names of the newly elected members.

Secretary Jellett: At the ballot for the election of new members just closed the following have been elected:

William Henry Bryan, St. Louis, Mo.; Ernst Glantsberg, Springfield, Mass.; Arthur Dudley Cross, San Francisco; William Kent, Passaic, N. J.; Martin J. Harris, Cramer Hill, N. J.; Richard Hankin, New York city; Charles F. Chase, Boston.

The President: The first subject this evening, according to the programme, is a paper by Mr. Eisert, of Baltimore, entitled: "A Suggestion for Determining the Heating Surfaces of Indirect Radiators." As Mr. Eisert is ill and unable to be present, and his paper is so technical that without a personal explanation from him, it would be almost useless to try to discuss it this evening. Therefore, the reading of the paper will be omitted and it will be published in our proceedings.

Topic No. 3: "What is the Best Means of Advancing the Interests of our Society?" was then discussed at great length. On motion the record of this discussion was expunged from the minutes.

Mr. Mackay moved that the Chair appoint a Committee on Membership, consisting of representative men composed of members in different sections of the country—one in New York, one in Boston, one in Chicago, one in St. Louis, one in Cincinnati, one in Buffalo and one on the Pacific coast. (Seconded.)

The motion was amended so as to leave the number and location of the members of the committee to the discretion of the Chair, and as so amended the motion was carried.

The Chair then appointed the following committee:

W. M. Mackay, chairman; A. E. Kenrick, D. M. Quay, Charles F. Tay, Henry Adams, H. D. Crane, Andrew Harvey, Prof. J. H. Kinealy, Prof. R. C. Carpenter, John Gormly, secretary.

The President: Gentlemen, if there is no further discussion upon this subject we will pass to No. 4: "The Consulting Heating and Ventilating Engineer's Relation to Owner and Contractor."

This topic was then discussed for considerable time.

The President: If there is no further discussion of this subject, we will pass to miscellaneous business. Is there any miscellaneous business?

Mr. Northcott: It seems to me appropriate that our President

should be a member of this committee upon the examination of buildings. He has had large experience in school house work, and I therefore move that the President be added to that committee. (Seconded.) I ask the Secretary to put the question on my motion.

Secretary Jellett: All in favor of the motion of Mr. Northcott, that the President be added to the committee referred to, will manifest it by saying aye; those of the contrary opinion, no. (Carried.)

On motion, the meeting adjourned.

PAPERS

OF THE

ATLANTIC CITY MEETING,

JULY 15, 1898.

XLIX.

SOME ACCEPTED TESTS OF VENTILATION—ARE THEY RELIABLE?

BY T. C. NORTHCOTT.

(Member of the Society.)

Most of the methods and instruments by which we measure the results of ventilation have come into use within a generation. They are comparatively new, and to some extent defective. At the beginning of my paper I wish to remind you that we are not to abandon methods of testing because they are defective until we have found other methods that are less defective. It was quite appropriate, for example, that distances should be measured by "a day's journey" when people had come to no agreement as to a more exact standard. I seek no abandonment of instruments which are the best we know for their purpose, but I think it important to recognize their shortcomings.

1.—Collateral to my subject, but not exactly of it, are demands sometimes, and altogether too often, imposed upon contractors which run all the way from a strain to an impossibility.

I have several times known contractors to be requested to guarantee that at no time shall there be more than two degrees difference in temperature between floor and ceiling in a ventilated room. In this company of experts it is needless to discuss a proposition so manifestly absurd. Yet I grieve to say that there were some who called themselves heating and ventilating engineers who bid without protest under this demand, and actually wrote it into their contract. So long as such ignorance is found there is demand for this society.

I wish to speak of a fallacy concerning the relation of exhaust and supply of air. I recently found upon my desk a request to bid upon some work where one of the requirements was "that 1,500 cubic feet per minute of air should be supplied to a room, and that an equal volume should be discharged through the ventilating exits." "Equal," mark you. What becomes of shrinkage in volume by reduction in temperature? How is the leakage to be accounted for? The architect who made this demand knew no better, and probably with limited

opportunities of investigation he could not be expected to know better, for he seemed to be supported in this unreasonable demand by the consent of alleged experts who accepted the condition and made their bids without protest. I will not stop to discuss this question before this audience. I simply refer to it as another illustration of a case where the instructed engineer should make a vigorous protest.

I now come directly to my subject.

2.—Tests for Carbonic Acid Gas:

To discover the degree of impurity of air in occupied rooms, it is usual to determine the proportion of carbonic acid gas. The excess of this gas over that which is normal to outside air in a clean locality is taken as showing the degree of impurity. For two reasons this test is only approximate.

In the first place, carbonic acid gas is not the only, nor the worst, poison discharged into the air of an occupied room. An eminent authority states that "a man of average weight throws off through the skin during the twenty-four hours about 18 ounces of water, 300 grains of solid matter, and 400 grains of carbonic acid gas." This is nearly three pounds of poisonous matter discharged into the surrounding air by every vigorous adult in each twenty-four hours. But less than one-third of this is carbonic acid gas. It is well known that the solid matter of excretion in an occupied room is a most deadly poison. We have no accurate means of testing its volume, except by laborious processes in the laboratory not available or practicable for general use. A well-regulated nose is the only instrument in general use which will detect the presence of this poison. We should always remember that the well-known odor of air vitiated by a crowd does not come from carbonic acid gas, but from the crowd poison which is represented by organic and decaying matter exhaled from the bodies of occupants. We exhale filth through every pore of the skin, and this discharge is quite as offensive and as poisonous as any other discharge from the human body. You have often remarked the pallid face, the dulled and flattened eye of a prisoner in many of our jails—and, I might also say, prisoners in some of our schools. This is not so much the result of the excess of carbonic acid gas as of that other form of crowd poison. A skillful experimenter housed a mouse in a closed cage, where he was compelled to breathe over and over the products of his own exhalation. The excess of carbonic acid gas was then withdrawn, or neutralized, and yet in a brief time the mouse died from crowd poison. But we do not

always thus "try it on the dog." You may take a crowded school room with an ample supply of pure air through an overhead register. Now lower a window from the top. The circulation of pure air will be ample through the room, but it will be almost entirely overhead. The children sitting just below this flowing current of pure air are discharging from the lungs carbonic acid gas, while both from lungs and skin they are discharging organic matter. Much of the carbonic acid gas is discharged upon the air at a temperature of about 92°. The organic matter—most of it—is not so warm. It is also heavier. Impelled upon the breath, the carbonic acid gas will at first ascend, because warmer than the stratum of air into which it is breathed. Most of it will be caught in the outgoing currents above the heads of the children, and thus be carried away through the open window, while most of the other form of crowd poison—and the deadlier form—will, because cooler and heavier, remain in the lower and occupied stratum of air. Now, let the experimenter come into this room and test that stratum of air in which the children are sitting. He will find it comparatively free from excess of carbonic acid gas. If he is unwise, he will announce the conclusion that the air which the children are breathing is comparatively pure. But it will be a mistake. I have often heard it remarked that men who work with carbonic acid gas (as it is used in some of the arts) do not show the ill effects which we would suppose. The reason is that an excess of carbonic acid gas is not the most deadly poison of vitiated air. Yet I concede that the test for carbonic acid gas in vitiated air is, under carefully guarded circumstances, approximately correct, and, if rightly used, is of great value. This is true because an excess of carbonic acid gas is ordinarily a close companion of all other forms of crowd poison. Its presence indicates the presence of its ally. Find the tail of a snake, and the head is not far off.

3.—The Lime Water Test:

This test aims to determine the presence of carbonic acid gas. Remember it does not, except by inference, determine the presence of other forms of crowd poison. It is not necessary that I attempt to describe the lime water test other than in a general way. It depends upon the fact that carbonic acid gas passed into and through lime water will precipitate the lime in the water, making the water which was at first absolutely clear to be more or less clouded and dense with chalky matter. The amount of carbonic acid gas discharged through the water determines the degree of density.

With the Wolpert Air Tester, for example, you are to determine

the volume of carbonic acid gas that is passed through the water by the number of times you have discharged a bulb full of contaminated air through the lime water before the water becomes so dense that a black spot at the bottom is obscured. Now it is evident that the experimenter may, or may not, exhaust the bulb, or air pump, to the last degree at each filling. He may, or may not, inadvertently fill the bulb from that limited area of air immediately surrounding his own head, and into which he has just that instant discharged the contents of his own heated lungs. This does not impeach the honesty of the operator. It is simply a question of his knowledge, his skill and precision.

Again: To determine when the black spot can no longer be seen through the lime water is a question of vision. It might be obscured to me, while you with better eyes can still see it. Everyone who has made use of this test knows how difficult it is to be quite sure when the vanishing point is reached.

The various lime water tests in popular use are thus defective, and to prove it I defy any two experimenters to make their tests at the same time, and in the same place, and in the same manner, and separately arrive at the same results. They will not do it, simply because the results are in each case only an approximation. But this test is not without great value, and we must continue to use it until something better is known. We should look with some degree of skepticism, however, upon any such test made by the experienced.

4.—The Anemometer:

The anemometer is the most useful instrument in determining the results of ventilation. I mean a good anemometer. I have seen some that are no better than an old-fashioned fanning mill. It should be delicately adjusted, and carefully kept so. We should remember that ventilation is, more than anything else, dilution, and so, after all, the best test of adequate ventilation is the anemometer test. And yet the anemometer, even if a good one, in the hands of an inexperienced or injudicious person, is an unscrupulous liar. I say the anemometer is—not necessarily the operator. He may be simply ignorant of the subject. Let me illustrate: You may take a box or room through which you shall flow a given volume of air. We will suppose that the air is being discharged at the rate of 400 cubic feet per minute. Now if the exhaust—at the floor, for example—be 144 inches long and only 1 inch high, and if the air is flowing at a velocity of 400 feet per minute, you will maintain the conditions of our problem. We will suppose that the air meter has a wheel 3

inches in diameter. You may set this anemometer in this shallow current and it will not serve to measure the outflowing air, simply because the current is not deep enough to attack the screw and impel the wheel. If now, without otherwise changing your box, or room, you shall close up the long shallow opening and make another opening 12 inches high and 12 inches wide, the area at the discharge will still be maintained. The former velocity being also maintained, the discharge will again be 400 cubic feet per minute. Now put your anemometer in this current and (making the proper correction for friction) it will register with fidelity.

The case I have supposed is an extreme one, yet we many times approach such conditions, or similar conditions, in actual work. So we come again to the fact that the results of even this best instrument we know—the air meter—may be only approximate, and it is clear that in the hands of an inexperienced person it may be of little value.

I conclude as I began: We must continue to use tests which we recognize as in some measure defective. We continue to use them because they are the best known. We shall be careful, however, to make these tests with a full knowledge of their shortcomings, and a disposition to carefully watch for every affecting circumstance. In the meantime we will urge invention to find better instruments for our purpose.

L.

A SUGGESTION FOR DETERMINING THE HEATING SURFACES OF INDIRECT RADIATORS.

BY H. EISERT.

(Member of the Society.)

When determining the heating surfaces of indirect radiators generally a good deal of guesswork is done, and, naturally, such can only be a case of "hit or miss." Sometimes the obtained result is further multiplied with a factor of safety, so as to be sure not to "miss" it. More often, however, this is not done, especially when "the job must be cheap." Another cause of so many misfits is the indiscriminate application and use of commercial indirect radiating surfaces, without proper consideration of prevailing given and created conditions. It is a well-known fact that under identical conditions the results obtained from different radiators will vary with the form, character and condition of their surfaces (plain, extended or pipe surface), and to some extent also with the material of the radiators. Furthermore, it is acknowledged that radiators of the same make and size will give different results, when applied and used under different conditions. This latter fact alone should be sufficient reason to abandon the usual mode of rating the value of a radiator heating surface by the total number of British thermal units (B. T. U.) emitted per square foot in one hour, without any reference to the conditions under which the result is obtainable.

An analysis of data from practical observation and from experiments made for that purpose demonstrates clearly that the relative value of a heating surface as such depends mainly on the arrangement of the surface and its condition, and to a very limited extent only on the material of the radiator, and that the efficiencies of radiators of the same value as heating surfaces further vary with the velocity of the air passing over such surfaces.

In the following let

k_0 denote the relative value of a radiator as heating surface, and

k the efficiency of such surface when the air passes through the radiator at a mean velocity of v feet per second.

This coefficient of efficiency represents the number of B. T. U.'s

emitted per square foot of heating surface in one hour per degree of difference between the temperature of the heating medium and that of the air in contact with the heating surface. Its relation to the relative value of the radiator as heating surface can be expressed by the equation

$$k = k_0 (1 + 0.0875 \, v^{0.9}) \quad \ldots\ldots\ldots\ldots\ldots \; 1$$

With the value of k thus established for a certain radiator, its heating capacity, expressed in cubic feet of air heated per square foot of surface in one hour, a given number of degrees from a given initial temperature can be readily ascertained.

The duty to be expected of any radiator, that is, the total number of B. T. U.'s emitted per square foot of surface in one hour, when the air in contact therewith is being heated from t_0 degrees to t_1 degrees, can be expressed by the general equation:

$$\frac{k\,(t_1 - t_0)}{\text{log. nap.}\,\dfrac{T - t_0}{T - t_1}} = \text{B. T. U.} \quad \ldots\ldots\ldots\ldots \; 2$$

when the heating medium is steam, of which the mean temperature, T, it can be assumed, is constant, and by

$$\frac{k\,(T_1 - T_e) + (t_1 - t_0)}{\text{log. nap.}\,\dfrac{T_1 - t_0}{T_e - t_1}} = \text{B. T. U} \quad \ldots\ldots\ldots \; 3$$

when the heating medium is hot water, of which the initial temperature, when entering the radiator, is T_1 and the final temperature, when leaving the radiator, is T_e.

Owing to the fact that the naperian or hyperbolic logarithms are rarely found in the hand-books commonly used, it is preferable to substitute their equivalent in common or Briggs' logarithms instead.

Now, it being known that

$$\text{log. nap. } x = 2.3 \log x,$$

the equations 2 and 3 can be transformed into

$$\frac{k\,(t_1 - t_0)\,r}{2.3} = \text{B. T. U} \quad \ldots\ldots\ldots\ldots\ldots \; 4$$

when the abbreviation r represents

$$\frac{1}{\log.\,\dfrac{T - t_0}{T - t_1}} \text{ for steam heating, and}$$

$$\frac{1 + \dfrac{T_1 - T_e}{t_1 - t_0}}{\log.\,\dfrac{T_1 - t_0}{T_e - t_1}} \text{ for hot-water heating.}$$

It has been found that during the process of raising the temperature of one pound of air one degree 0.2375 B. T. U.'s will be absorbed by that air. This value is termed the "specific heat" of air.

In the general practice of heating and ventilation, however, it is preferable to express the quantities of air, coming into consideration, in volumes at a certain temperature, usually + 70° Fahr. At this temperature one cubic foot of air weighs

$$\frac{0.0807}{1 + 0.00204\,(70 - 32)} = 0.07489 \text{ pounds.}$$

Hence, in order to raise the temperature of one cubic foot of air from t_0 degrees to t_1 degrees

$$0.07489 \times 0.2375 \times (t_1 - t_0) = \frac{t_1 - t_0}{56} = \text{B. T. U.'s} \ldots 6$$

must be absorbed.

If it now can be assumed that all the heat omitted by one square foot of heating surface is utilized to raise the temperature of a cubic foot of air from t_0 degrees to t_1 degrees, the following relation must exist, viz.:

$$a\,\frac{t_1 - t_0}{56} = \frac{k\ (t_1 - t_0)\ r}{2.3} \ldots\ldots\ldots\ldots\ldots\ldots 7$$

By transformation, and at the same time introducing for k its equivalent from equation 1, it follows:

$$a = 24.32\,k_0\,(1 + 0.0875\,v^{0.5})\,r \ldots\ldots\ldots\ldots 8$$

This value represents the heating capacity of the radiator, expressed in cubic feet of air heated a given number of degrees per square foot of surface in one hour from a given initial temperature.

In order to admit of the free passage of air through any radiator, the arrangement of its heating surface must be so as to offer the proper opening for that purpose. This opening, or area of air passage, always bears a certain relation to the heating surface of the radiator, varying only with the arrangement of the same.

In all cases, therefore, whether the radiator consists of pipe coils or individual cast iron sections, the area of air passage through the radiator is either known or readily ascertained. Its equivalent may be expressed by σ, representing the free air passage through a radiator in square inches per square foot of heating surface for each unit of depth of radiator. This unit may represent either one section of a sectional cast iron radiator or one pipe of a pipe radiator; that is, a radiator may be n sections high or deep or n pipes deep. Equation 8, states now that one square foot of surface will heat a cubic feet of air under certain conditions. This quantity of air must pass through the available opening of the area $\frac{\sigma}{n}$ square inches at a certain veloc-

ity, which, as such, affects the efficiency of the heating surface as expressed by equation 1.

The relation between the quantity of air passing through an opening of the area $\frac{\sigma}{n}$ square inches at a velocity of v feet per second is expressed by the equation

$$a = 25 \frac{\sigma}{n} v \ldots\ldots\ldots\ldots 9.$$

By introducing into equation 8 the equivalent for a from equation 9, it is

$$25 \frac{\sigma}{n} v = 24.32\ k_0 (1 + 0875\ v^{0.9})\ r,$$

from which follows, by transformation:

$$\frac{v}{1 + 0.0875\ v^{0.9}} = \frac{24.32\ k_0\ r\ n}{25.\ \sigma.}$$

For practical use, however, this equation is more suitable in the form:

$$\frac{1.028\ v}{1 + 0.0875\ v^{0.9}} = \frac{k_0\ r\ n}{\sigma} \ldots\ldots\ldots\ldots 10.$$

In equation 10 the value r is fixed by the temperatures, and the values k_0 and σ by the arrangement and character of the surfaces, while the values v and n are variable, but depending upon each other. The most convenient way of solving this equation for n as well as for v is by the graphical method. To this end a curve can be constructed, of which for any abscissa of the value v the corresponding ordinate represents the value $\frac{1.028\ v}{1 + 0.0875\ v^{0.9}}$. It is now obvious that as soon as the values $r\ k_0, \sigma$ and n are given by prevailing conditions, the value $\frac{1.028\ v}{1 + 0.0875\ v^{0.9}}$ is known by equation 10, and as this value represents an ordinate of the constructed curve, the value of the corresponding abscissa, which represents the value v, that is, the velocity of the air passing over the heating surfaces, can directly be read off. Furthermore, if for some reasons the velocity v of the air should be given, the corresponding ordinate to the abscissa of the value v represents the value $\frac{1.028\ v}{1 + 0.0875\ v^{0.9}}$ and the required number of pipes or for the depth of the radiator can be determined by

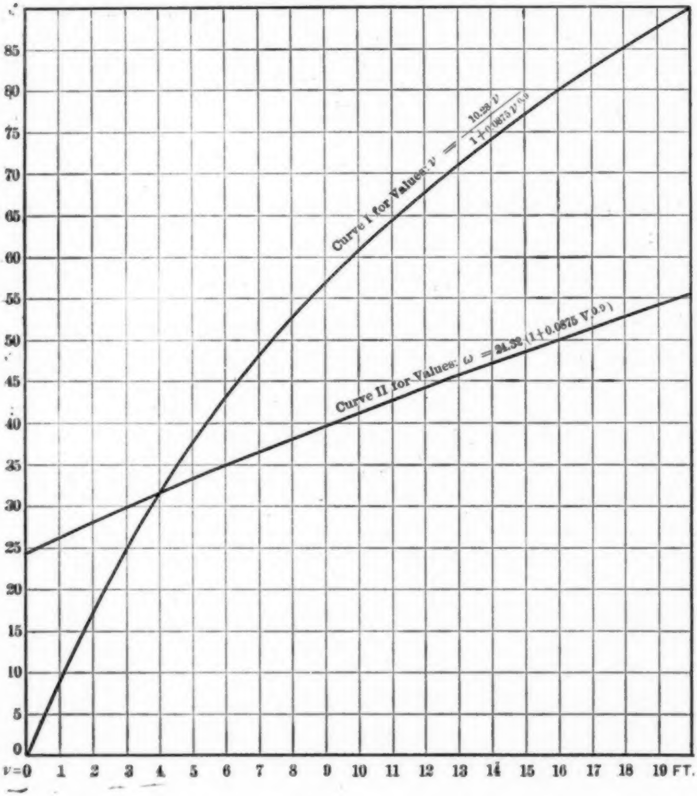
$$n = \frac{\frac{1.028\ v}{1 + 0.0875\ v^{0.9}} \cdot \sigma}{k_0\ r} \ldots\ldots\ldots\ldots 11.,$$

which is derived by transformation of equation 10.

In order to read off the value $\frac{1.028\ v}{1+0.0875\ v^{0.9}}$ more accurately, the curve I. on diagram has been constructed, so that for any value of the abscissa v the corresponding ordinate represents the value

$$V = \frac{10.28\ v}{1 + 0.0875\ v^{0.9}} \quad \ldots\ldots\ldots\ldots\ldots\ldots 12$$

The curve II. on the same diagram has been constructed so that



for any value of the abscissa v the corresponding ordinate represents the value

$$\omega = 24.32\ (1 + 0.0875\ v^{0.9}) \ldots\ldots\ldots\ldots 13$$

The practical application of the diagram is demonstrated by the following illustration:

The meteorological conditions of the locality fix the temperature

t_0, the selection of the heating medium determines its temperature T, respectively T_1 and T_e, and the local conditions of the room or rooms to be supplied with heated air determine the temperature, t_1, the air has to be heated to; thus the value τ is fixed. It will greatly facilitate the calculation to have the values τ for various conditions that are liable to repeatedly occur compiled in a tabulated form for ready use.

The selection of the kind of radiation to be used fixes the values k_0 and σ.

These latter data now establish the relation between n and v. Sometimes it may be desirable that the velocity of the air passing through the radiator exceed not a certain limit, or else may be fixed otherwise. In such case the value v is assumed tentatively and n determined by

$$n = \frac{V.\sigma}{10.k_0\ \tau} \dots\dots\dots\dots\dots\dots 14$$

in which equation the values σ, k_0 and τ are given and the value V, according to equation 12., is read off the diagram. Very seldom, however, will equation 14. give a result that exactly suits the practical conditions, therefore the nearest convenient and suitable value of n is V determined by

$$V = \frac{10.k_0\ \tau.n}{\sigma.}$$

that is, equation 10., modified according to equation 12.

The ordinate V of curve I. determines the value of the corresponding abscissa v, which, at the same time, is also an abscissa of the curve II. and the corresponding ordinate by that curve represents direct the value

$$\omega = 24.32\ (1 + 0.0875\ v^{0.9})$$

so that by combining the equations 8. and 13. the heating capacity of the radiator is determined by

$$a = \omega\ \tau.k_0. \dots\dots\dots\dots\dots\dots 16$$

The duty that can be expected from this radiator under the given condition is, according to equation 7,

$$U = a\ \frac{t_1 - t_0}{56} \dots\dots\dots\dots\dots\dots 17$$

that is, the number B. T. U.'s emitted by one square foot of surface in one hour, which in case of low pressure steam heating is equivalent to a condensation of about $\frac{1.04.U}{1,000}$ pounds of steam per square foot of heating surface.

In concluding a few remarks may be added, relating to what

herein has been termed the relative value of a radiator as heating surface.

Recognized authorities on the subject claim that smooth steam heated surfaces transmit to the air in contact therewith from 2.248 to 3.679 B. T. U.'s per square foot in one hour per degree difference between the temperature of the steam and that of the air, varying with the proportion between the outer and inner surfaces of the radiator and with the extent to which the entire heating surface of the radiator is accessible for the air passing through. But owing to the usual arrangement of the heating surfaces in the various types of radiators, it can be safely assumed that the actual obtainable efficiency of the heating surfaces is about one-third less. At the same time it is stated that even under the most favorable conditions, the value of extended surfaces is limited. The relative value of the extensions as heating surface is about from 0.3 to 0.45 of the relative heating value of the same radiator's prime surface. If now the proportion of the extended to the prime surface of a radiator should be 3 : 1, the relative heating value of such radiator with extended surfaces would range from

$$\frac{3 \times 0.3 + 1}{4} = \frac{1.9}{4} = 0.475 \text{ to}$$

$$\frac{3 \times 0.75 + 1}{4} = \frac{2.35}{4} = 0.5875$$

of that of a radiator with smooth surfaces of the same character as its prime surface.

While it is true that radiators with extended surfaces contain large surfaces within a small space, it is equally true that this is achieved only at the cost of its relative value as heating surface. Though the above cited data refer to smooth heated surfaces, which naturally are represented by radiators of some form, it must be considered that these data were derived from experiments made under conditions that rarely occur in general practice. With our commercial radiators and under average conditions, it is safe to say that only one-half to two-thirds of these values are actually obtained.

A careful study and analysis of data, which are also frequently referred to by our writers on this subject, and a comparison with other results and conditions, have led the writer to assume for his own practical use, that the relative value k_0 of indirect radiators as heating surfaces ranges from 1.35 for cast iron sectional radiators with largely extended surfaces to about 2.2 for coils of 1″ diameter wrought iron pipes arranged vertically in staggered rows.

For hot water heating these values may be increased about 15 per cent.

While it is not claimed that these values stand irrepealable, it may be stated that the results obtained thus far compare favorably with good practice.

Valves of $\tau = \dfrac{1}{\log \dfrac{T - t_o}{T - t_i}}$ for $T = +220$ F. (low press. steam).

Intermediate valves can be obtained by interpolation.

$t_i =$	$t_o =$							
	− 20°	− 15°	− 10°	− 5°	0	+ 5°	+ 30°	+ 40°
+ 40°	8.000	8.635	9.392	10.317	11.472	12.957	......	......
+ 65°	5.266	5.544	5.835	6.188	6.575	7.032	11.310	15.407
+ 70°	4.399	5.130	5.417	5.680	6.010	6.396	9.740	12.633
+ 75°	4.569	4.770	4.991	5.240	5.523	5.846	8.519	10.660
+ 80°	4.272	4.446	4.660	4.853	5.0[illegible]4	5.388	7.540	9.166
+ 85°	4.002	4.154	4.320	4.507	4.714	4.948	6.737	8.000
+ 90°	3.755	3.890	4.035	4.196	4.377	4.577	6.067	7.075
+ 95°	3.530	3.648	3.776	3.920	4.073	4.256	5.499	6.315
+ 100°	3.320	3.426	3.540	3.663	3.799	3.948	5.011	5.680
+ 105°	3.130	3.222	3.320	3.430	3.550	3.680	4.585	5.140
+ 110°	2.950	3.034	3.120	3.218	3.320	3.436	4.214	4.680
+ 115°	2.710	2.779	2.861	3.021	3.113	3.213	3 883	4.273
+ 120°	2.630	2.692	2.764	2.840	2.920	3.010	3.588	3.918

Valves of $\tau = \dfrac{1 + \dfrac{T_i - T_e}{t_i - t_o}}{\log \dfrac{T_i - t_o}{T_e - t_i}}$ for $T_i = 170°$ and $T_e = 160°$

(Hot water.)

t_i	$t_o =$						
	−5°	0	+ 5°	+ 10°	+ 15°	+ 20°	+ 25°
65°	5.825	6.308	6.398	7.6[illegible]0	8.660	10.633	11.322
70°	5.212	5.600	6.063	6.625	7.333	8.307	9.378
75°	4.692	5.006	5.375	5.816	6.358	7 018	7.954
80°	4.241	4.502	4.800	5.151	5.571	6.080	6.711
85°	3.857	4.064	4.313	4.595	4.927	5.324	5.847
90°	3.519	3.691	3.887	4.121	4.388	4.703	5.078
95°	3.212	3.[illegible]50	3.524	3.708	3.929	4.181	4.477
100°	2.941	3.064	3.202	3.387	3.530	3.737	3.973

LI.

TOPICAL DISCUSSIONS.

TOPIC NO. 3.

"Boiler furnaces for steam power installations."

The following discussion was contributed in writing by Mr. M. C. Huyett.

Most of the factors which must be considered in detail and be combined in the unit of a complete heating and ventilating plant, such as is installed in large office and school buildings, have been discussed in the meetings of our society. We have, however, ignored the question of fuel cost, and smokeless combustion where bituminous coal has been used. If a client has been using anthracite coal, we accept that condition and develop the work accordingly; if he has been using bituminous coal and decides to adopt the use of anthracite coal—in order to suppress a smoke nuisance—we accept the situation, regardless of the fact that fuel cost will be increased 40 to 60 per cent.

It is the purpose of this brief paper to give some fuel data as a basis for the discussion of mechanical smokeless furnaces.

The Central High School building, Detroit, Mich., has been used two winters; it is modern in every detail of equipment. The power plant has four horizontal tubular boilers, aggregating 428 horse power. The furnaces were plain grates, hand-fired.

FUEL DATA.

Sept., 1896, to March 1st, 1897:

194	tons,	790	pounds	Jackson lump coal @ $2.24	$435.94
43	"	1,140	"	Pocahontas R. M. " " 2.34	102.34
255	"	1,300	"	" " " " 2.49	636.55
8	"		"	" " " " 2.75	22.00
189	"	1,730	"	" " " " 2.85	542.11
404	"	620	"	" " " " "	1,152.27
1,095	"	1,760	"		$2,891.21

and from March 1 to the end of school term,

189 tons, 1,300 pounds Pocahontas R. M. @ $2.83	536.04
	$3,427.25

The building is in a fine residence part of the city, and complaints of "smoke nuisance" and threats of suits were frequent. The use of

anthracite coal was considered favorably, and the consulting engineer for the board estimated that 1,000 tons would be required. Proposals were advertised for, and the lowest bid was $4.88 a ton. At the same time proposals were asked for Jackson Hill (Ohio) nut and slack; the lowest bid was $1.69 delivered in the building.

Mechanical furnaces were installed in August, 1897.

FUEL DATA.

Sept., 1897, to March, 1898:

806 tons Jackson Hill nut & slack @ $1.69	$1,362.14
The engineer then estimated that 150 tons would complete the school term @ $1.69	253.50
	$1,615.64

If the engineer's estimate for the incomplete part of the term proved to be correct, the economy in favor of the mechanical furnaces and cheap bituminous coal would be $1,811.61.

The known quantity is the two school terms to March 1—$2,891.21, — $1,362.14 = $1,529.07, economy.

The unknown quantities are a reduced volume of ventilation applied late in the winter of 1897, and an added duty requirement for the operation of two large elevators for the full school term of 1897-8.

The calorific value of Pocahontas run of mine per pound of dry coal, by test, 14,289 B. T. U., and Jackson Hill nut and slack, by test, 12,139 B. T. U. Anthracite coal averages lower in calorific value than Pocahontas, hence it is safe to assume that had anthracite been used 1,000 tons would have been required and the fuel cost have been $4,880.

There has not been a single complaint of smoke nuisance whilst burning that 1,000 tons of bituminous nut and slack coal. Almost continuously the chimney top has been absolutely smokeless.

When working a boiler at full duty rating, of 10 square feet of heating surface per horse power, with a mechanical furnace

3.16	pounds	Pocahontas R. M.	was burned per horse power hour.
3 74	"	Jackson nut & slack	" " " " " "
4 4	"	Hocking Valley slack	" " " " " "
3.65	"	Belmore pea	" " " " " "
4.1	"	Cherokee Kansas slack coal	" " " "

I have test data with slack coal hand-fired and like coal mechanically fired; the economy favored the mechanical furnace 20 per cent.

I participated in a test of smokeless furnaces and made smoke charts, backed by 623 photographic negatives, made at stated intervals; on each negative was placed (prior to development) the number and the exact time of exposure.

Mechanical Furnaces vs. Hand-Fired Furnaces.

In support of the statements made with regard to the economy of

mechanical furnaces over hand-fired furnaces, I quote from a report of a test made by William H. Bryan, M.E., of St. Louis, Mo.: "The fuel was slack coal from the Cherokee (Kansas) mines, which is about the same quality as Illinois coal. The boiler showed an average efficiency of 56.64 per cent. * * * The boiler was being worked above its rated capacity;" that test was considered satisfactory. The furnace was of special construction. A mechanical furnace was tested last winter at the Kansas City, Mo., water works; like coal was used and the boiler was worked 34 per cent. above a rating of 10 square feet per horse power, and its efficiency was 74 per cent.—30.7 per cent. higher than that of the specially constructed hand-fired furnace.

TOPIC NO. 4.

"The Consulting Heating and Ventilating Engineer—His Relation to Owner and Contractor."

Secretary Jellett: This is a subject that ought to be discussed. It is also the subject, I find, of a paper which was presented at the June meeting of the Society of Mechanical Engineers by one of our newly elected members, Mr. W. H. Bryan.

I have his paper with me. It is a difficult question to discuss properly. The consulting engineer stands in the same relation to the owner and contractor that the architect does. He is employed because an owner believes he has the ability to plan the mechanical equipment for heating and ventilating of his building in the best possible manner and to spend his money to the best possible advantage. The consulting engineer must not only have the confidence of his employer as to his ability as an engineer, but the employer must believe in his integrity as well. He therefore must be above suspicion as to his honesty, and he must be qualified from an engineering standpoint, or else he does not meet the requirements. At the same time he bears a relation to the contractor which must not be overlooked. If the engineer or the architect so conducts his business in an arbitrary and unfair manner that he cannot get good contractors to do his work, then he is working to the detriment of the owner. What is required to get the best results is an engineer of ability, and an honest contractor who knows his business. It should be the duty of the consulting engineer, after having prepared his plans, to pass on the qualifications of the contractor who is to do the work. If he knows that the man who is to do the work is not qualified, it is his duty to the owner to say so, no matter whom he hits. It is a delicate position to take; but it is one that he must take, because honesty to one's

client covers a great deal more than merely making the plans and specifications carefully. This opens up a field of discussion as to the relation between the engineer and the contractor, and it makes the question rather complex. For example, take the matter of specifications for boilers to be erected in a building where the space in which to place the boilers is so limited that it practically restricts the type of boiler, and where it may restrict the make of boiler within certain lines. I had a case of this kind during the past week in an important building, where the space in which to put the boiler was just 13 feet between two walls. We wanted a certain amount of horse power in two separate boilers, and room to attend to the boilers. I looked up the different plans and makes of boilers, and I found that out of the various types there were but three that would go in that space and give the required results. The owners wanted more bids than three. I said: "If you move the division wall we can consider other boilers." The moving of this wall meant the underpinning of the whole building and five or six thousand dollars expense, which they did not want to spend. They then thought that they would ask bids from all the boilermakers that they had intended to, notwithstanding they knew that all but three would necessarily be thrown out because of the limited space. I objected. I said that it was not fair to ask men to bid, knowing that their bids could in no event be accepted, and I finally prevailed, and they narrowed the bids to the parties who could actually do the work. Now these are questions that every engineer finds coming up from time to time. He must decide them. If he is weak-kneed about it, and allows the owner and the architect to decide, knowing that they are working an injury to a reputable contracting firm, the engineer is doing wrong; he is not doing his duty. Again, there is another side to it. If you, as a consulting engineer or representing a board of trustees or owners and a number of bids come in, and one of them is so much below others that you feel sure the man has made a mistake—and he is a reputable contractor—it is your duty to call your client's attention to the fact that the bid is too low, and it is also your duty to ask the contractor to examine his estimate to see if he has not made some omission. This is not the commonly accepted way of working, I am sorry to say, but it is the right way. I contend that no owner has a right to accept a bid when his engineer has advised him that it is below the cost of the work without giving the contractor an opportunity to check his figure, and it is not honest in the engineer to omit to advise the owner that the bid is too low when he knows the cost of the work. Now, these things come up from time to time, as we all know, and we must not shrug our shoulders and dispose of the matter by saying: "That fel-

low is in a hole." No man has a right to ask another to do work for him at a loss, nor has any man a right to expect that a man working for him will give his time and attention to saving him money on a job or giving him increased benefits unless he is getting fair return for his work. I have had cases where I have known a bid to be too low to even buy the material. I had one case about a year ago, where I called attention to the fact that the bid was too low to purchase the material. The first question asked by a member of the committee was: "Isn't he financially capable of carrying out the contract?" I said, "Yes." "Then it is none of our business." I said, "Yes, it is; you have no right to accept it when I tell you that it will not buy the material, because the minute you sign the contract it is my business to exact from that contractor the full measure required by the plans and specifications. I have no option after that time, but it is my duty now to tell you that that bid will not cover the cost of the material, let alone the labor and a reasonable profit." One of the members of the committee said, "I think you are right," and we sent for the contractor and asked him if he had gone into the details of his bid carefully. I told him frankly that his bid was low, and that I wanted him to be satisfied in his own mind that he had made his calculations correctly; and if he felt sure that he had done so I had nothing to say, and was ready to award him the contract. He went away, and returned and stated that he had omitted an item of pipe covering, $375, and if that was added he was perfectly willing to go ahead. I believed then that he had not found the main leak, and a year later he came to me and said: "Mr. Jellett, I am sorry that I didn't go further into that matter. I am out on that contract $2,000; I not only have not made any money out of it, but I am out just $2,000." Now, I think I treated the man fairly, but at the same time I did my duty to the owners. It is that side of the question that I think would bear discussion. I think we should also consider not only the men we work for, but the men we are looking after, the man who is under our direction, and it would be better for the owner as well as the contractor, because the man who is not making any money on a job certainly has no interest in giving to it the close attention he should do in order to do an honest piece of work.

Mr. Northcott: I would like to hear some further discussion of this subject. I think it is a subject of burning interest. We labor under serious difficulty in this matter. Heating and ventilating is a new science. The heating and ventilating engineer is a new factor in public progress. He was brought into being by an organized effort of society. He is not known in the statutes. He has very largely come into existence by his own endeavors and through his own

method of arriving at knowledge. The result is this: We have some highly capable, conscientious, honorable men who are acting as consulting engineers and who are not contractors, and who are not allied with manufacturers; they are real experts and are qualified to do what they profess to be able to do, but there is no provision in our law, there is no custom, which prevents any man who wishes to do so to hang out a shingle as a consulting engineer. So, just as you can have doctors all the way from a corn doctor up, you can have consulting engineers. That is, the possibility is there. You can have consulting engineers from absolute inexperience and incompetency up to a high degree of efficiency. It is no detriment to those few men who are competent and recognized consulting engineers to say that there is a large amount of ability among contracting engineers that is perhaps equal, or, at any rate, worthy of the respect of the public, and that engineer who, contracting and placing his guarantee upon his work, is obliged to pay for his mistake, is the man that is very likely to take seriously to heart any lesson that he learns on a job. Now then, if you should take Mr. Jones, a competent contracting engineer, a man competent to design the system and to install the plant from first to last, and with his organized force to put it into operation, and compel him to put a guarantee upon work which has been specified by Mr. Smith, we will say, who is a consulting engineer, possibly incompetent, possibly inferior to Mr. Jones, you have done an injustice to Mr. Jones, haven't you? And there is not a contracting engineer but what has taken an architect's specifications and figured on them just with that feeling. Now, is it possible that a question of such vital interest as this is going to be whistled off right now? I haven't anything more to say on it, but it seems to me that somebody must have.

Mr. Harvey: I take it that the ground has been gone so fully over and in detail, with Mr. Jellett's description of the case he referred to that I think we can all say, "Yes, that is so." But to find the remedy is another thing.

Mr. Northcott: We will vote him a medal if he can find a remedy. If Mr. Harvey will allow me to continue what he has started, my impression is we will find the remedy just where it has been found in other professions, by statutory provision. For example, architects will devise an intricate system of heating and ventilation. They are then acting as consulting engineers, are they not? Possibly they never have handled a building of that description before, and yet they call upon a body of experienced men to come in and guarantee that work. Now, the time is coming when the law will provide that specifications of that kind must be drawn by competent consulting, heating and ventilating engineers.

Mr. Harvey: There was a case in Detroit where a certain architect drew specifications for heating a school, and he signed a guarantee as well, but when the work was done it did not prove satisfactory—there was not sufficient heating surface—and the Board of Education brought suit against the contractor. The contractor won, because the question was asked in court, "What were these specifications for if not to specify?" They did specify a certain amount of heating surface, and after having specified that amount of heating surface, and the contractor having put in all that was called for, he of course had no further responsibility, any more than that he was to do work that was satisfactory, as far as it went. So I suppose that if an architect should draw plans and specifications and did not know his business thoroughly, and a contractor should take a contract to do the work in accordance with those plans and specifications, the party that the work was being done for would be the sufferer unless the architect could be held responsible.

The President: We had a case where an architect drew certain specifications, coupled with a guarantee, and I was afraid of that guarantee, and I went to our attorney about it. Our attorney said: "If you can show that you have delivered each and every part of the apparatus and fixtures as called for in the specifications, and erected them properly and in a thoroughly first-class and workmanlike manner, even if the apparatus fails to perform the functions that the guarantee calls for, you can collect your money." I put in a bid, and, though I did not get the contract, I know the thing did not work and that it had to be changed.

Mr. Northcott: Then the owner is being imposed upon, for he is constantly being led to suppose that he is getting a valid guarantee there. It is a deplorable state of things, to say the least.

The President: Mr. Secretary, do you know anything regarding the action of the Committee on Uniform Contracts, if by our annual meeting they will have formulated something that may be used?

Secretary Jellett: I do not know. I know they were in correspondence some time ago.

The President: That would have a strong tendency to help out in this matter that we have been discussing.

Secretary Jellett: I do not think the consulting engineer has a right to require from a contractor anything but good material and good workmanship. He has no right to require results from him. I have no right to ask you to guarantee my figures. When I am asked to bid on a set of plans and specifications, if I find at the end a clause, "These are the sizes that will be accepted, but the contractor will be required to guarantee certain results," which they go on and

define, the specifications amount to nothing, because at once you have to study the whole job yourself. It is a peculiar condition, and I think it is due to the fact that the engineering business in connection with heating and ventilating is rather new. I know of no other business where a man comes in to buy goods in which he does not exercise his own judgment. If a man wants to buy a suit of clothes and agrees upon the price, and he afterwards comes back and says the suit doesn't fit him, he does not ask the tailor to give him another kind of cloth, but he asks him to make the suit fit him. The purchaser is supposed to exercise his own judgment. The purchaser of apparatus for heating and ventilating, being ignorant, calls upon the engineer to represent him, and he should be willing to take the engineer's judgment. If he does not get what he ought to get he has made a mistake in his engineer.

Mr. Northcott: Is it not true, though, that the consulting engineer does as a rule exact a guarantee of good results?

Secretary Jellett: Yes, there are a great many such cases. It would not stand in court, though.

Mr. Northcott: There is the point I make, that it is unjust.

The President: An architect will demand a guarantee on his own knowledge, sometimes.

Secretary Jellett: The difficulty has been that there have been no qualifications required from architects. I understand the Institute of Architects has been considering that question.

Mr. Northcott: My experience with architects is that the less they know about a subject the more rigid they will make the specifications.

Mr. Mackay: On that question of guarantee, I made specifications for the heating and ventilating of a building in a certain city, and a well-known contractor estimated on the work. The contractor wanted to make some changes in the material specified. I was not in touch with the owners of the building, only as I went there once or twice a month. The heating contractor said to the owner: "I will not guarantee that apparatus as it is specified." That immediately took the pins from under the owner, and he felt that something must be wrong if a good local contractor wouldn't guarantee the work. It was done for a purpose. The owner wrote me on the subject, and I wrote back that the contractor was not asked to guarantee the apparatus; I had done that; but he was merely asked to furnish a certain amount of material and labor. In that case if I had not been as close to the owner as I was he would have been influenced by it, and even as it was, he was somewhat influenced by it.

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ERRATA.

Page 21.—Fifth line from bottom. Mr. A. P. Fowler should read Mr. A. H. Fowler.

Page 21.—Third line from bottom should read "receive the ballots at three o'clock."

Page 27.—The name of A. A. Jellett should read S. A. Jellett, Secretary, in both places; tenth line from bottom should read "I declare the following officers duly elected."

Page 33.—Twenty-first line from top should read "would have to put the Society to the expense of sending these."

Page 241.—The name Mr. R. M. Gettis in the seventh, twelfth and fifteenth lines should read Mr. R. M. Geddes.

Page 250.—Eighth line from bottom should read President Wolfe, instead of President Mackay.

Page 255.—Fifteenth line from bottom of page should read: "After roll call President Wolfe addressed the meeting as follows:"

Page 258.—Twelfth line from top should read as follows: Hankin, New York City; associate, Chas. F. Chase, Boston.

TOPICAL QUESTIONS, DISCUSSION OF.

TOPICAL DISCUSSIONS AT ATLANTIC CITY MEETING.